WA-RD 86.1

Use of Video Data Acquisition for Structural Inspection

Final Report
April 1986

Washington State Department of Transportation
Planning, Research and Public Transportation Division
In Cooperation With
United States Department of Transportation
Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
WA-RD-86.1		

4. Title and Subtitle	5. Report Date
Video Recording System for Inspection of Large Structures	April 1986
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
9. Performing Organization Name and Address University of Washington Department of Civil Engineering Seattle, WA 98195	10. Work Unit No.
	11. Contract or Grant No. Y-2870
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered Final Technical Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Study was conducted in cooperation with the U.S. Dept. of Transportation, Federal Highway Administration.

16. Abstract

The significant change for the last few years is the increase in resolution, and decrease in required illumination level for video image recordings. Such developments provided the basis for this research. The results indicate that the video recordings suitable for inspection of portion of structures. Particularly those which are hardly accessable, are in deep shadows or under water. Using f=16-160mm 200m optics the recording distance is 5-150 ft and 3-6 ft under water. The resolution of the system is satisfactory. It is possible toform images in nearly complete darkness (night time). Therefore, structural parts in deep shadows can be inspected. It recommended that video-recording augment the visual inspections after certain modifications.

17. Key Words	18. Distribution Statement
Resolution. Video recording. Turbidity, I-lumination IR Filter, U.V. Filter, Photogrammetry	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	88	

Form DOT F 1700.7 (8-69)
HWY FORM 341-004 6/72

USE OF VIDEO DATA ACQUISITION FOR STRUCTURAL INSPECTION

by S.A. Veress
Principal Investigator
and
Yeongji Kim
Shiahn-Wern Shyue
Research Assistants

Washington State Transportation Center

Civil Engineering
University of Washington
Seattle, Washington

Final Report

Research Project Y - 2870

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation

April 1986

FINAL TECHNICAL REPORT

Conclusion and Recommendations

List of Figures

List of Tables

CONCLUSION AND RECOMMENDATION

This research is an evaluation of a video camera system to comply with structural inspection.

The video camera system first and foremost is an optical system and, as such, can only be used for visual inspection. The camera is capable of producing a technically usable image at 2.5×10^{-4} foot candle illumination level. This means that the video images which were made in nearly total darkness are interpretable, and the pictures are of high resolution at that level of illumination.

Because of this property, the video system is not replaceable with the conventional camera, due to the fact that the conventional camera cannot produce any image at that low of a level of illumination during daytime on certain underneath portions of bridges. Also, flash or strobe lights are ineffective at that distance. The most desirable use of video recording is to obtain an interpretable image for inaccessible areas. For areas which are easily reachable visual inspection is more desirable, however, the video recording can be used for documentation. The best utilization of the video recording system is to augment the present inspection system.

The system needs substantial modifications before implementation. The required and suggested modifications are discussed below.

The present zoom lens which has f = 16-160 mm. is effective from about 3 feet to 150 feet above the water and 3 to 6 feet underwater. This optical system has a built-in electric motor remote zoom system. This solution makes the camera too heavy (18.2 lb). More than half of this weight is the lens.

The automatic zoom is judged as convenient but not mandatory, and should be replaced by the manual zoom system which weighs only 2.5 lb.

The aiming of the camera in its present form is rather difficult because

the cameraman must watch the monitor to obtain a visual image of the object. It is, therefore, recommended that the selected lens should be a 'see-through' optical system which would eliminate this problem completely. There are a large# number of lenses available on the market which can be used with the common "C" mount of the camera.

During this instrumental evaluation research it was a general problem to identify certain parts of a structure under recording. This problem is particularly dominant when long focal length is used. The video tape recorder is equipped with audio recording, therefore, the parts of the structure should be identified by voice recording. In order to accomplish this a microphone with a proper cord is all that is required. If the cameraman simultaneously provides the voice recording with the video recording then a complete record and identification is obtained from the structure.

The resolution of the video system is satisfactory, however, it is somewhat restricted by the monitor which has a 960 T.V. line resolution. The resolution could be increased further by a high resolution monitor. There are 1025 T.V. line resolution products on the market but the change to a higher resolution monitor is not recommended.

The range of recording with the present system is 3 to 150 feet. This may be extended by using a different zoom lens such as a Sony J 25 x 11.5 BIE which has f = 12-288 mm. This lens would increase the range to 250 feet.

The long focal length lens cannot be utilized underwater, because the visibility range is reduced by the turbidity of the water, therefore, underwater recording a wide angle f = 16 mm. lens is recommended. This type of lens weighs only 12 ounces and forms a sharp image from 2 feet to infinity, so, it can be used for rather simple operations either by a diver or by remote control.

The video camera was mounted on a tripod during this evaluation project to obtain proper stability. If short focal length is used, such stability is not required, however, if a long focal length is used, it is a must. The tripod does not provide the mobility which may be desirable in some instances, therefore, it is recommended that a broadcast-type shoulder mount be used in place of the tripod.

The ultra-violet filter proved to be useful. It increased the contrast and in particular it delineated rusted areas on steel bridges. The use of an infra-red filter does not prove to be effective as it is unable to provide the separation of wavelength in the thermal infra-red region. As a consequence, further research is required on obtain information about lamination of bridge decks from infra-red thermography.

1. Introduction

The maintenance of the structures of our highway system is an utmost task. The difficulty of this task is compounded by conditions associated with the inspection of structures, particularly of bridges. Two of the most important conditions is the inaccessibility and the low, or near zero, illumination of certain structural elements. It is, therefore, of general interest to develop a method, and evaluative instrumentation which is capable of recording the structures remotely under near zero illumination.

1.1 Background Studies

The technical advances of the last few years permit the quantitative utilization of video-recordings. These advances can be classified into two major areas, namely; high resolution of video-images and low illumination level to obtain usable pictures. The minimum illumination level for these cameras range from 2.5×10^{-5} to 0.2 foot candles. These properties permit use of recording devices for surface and underwater data acquisition in any weather conditions.

The wavelength response of these photo-cathode recording tubes is 400 to 1000 milimicrometre wavelengths. The peak is from 500 to 800 nm. This indicates that the ultraviolet and the infrared recording capability of the video system must be investigated about the possible technical use for structural inspection.

Further, if one utilizes optical filters, thereby filtering out any other wavelengths but the ultra violet wavelengths, then the subsurface conditions may be visibly emphasized, and enhance the pictorial recordings.

The application of video-cameras as a means of data-acquisition contributes to basic research. In the literature these already have been reported to be used for thermo-vision systems whereby thermal images indicate material discontinuity of defect as a function of temperature change.

1.2 Problem Statement

The methodology and the utilization of this video camera form the data acquisition should be executed in phases. The first phase of the research is a complete equipment study and evaluation on limited equipment basis. This report is the final technical report of this phase.

The second phase should be the extension of equipment and utilization of special methodology development of using video-data acquisition.

The objective of this research, therefore, is equipment evaluation. The evaluation is directed toward the inspection of the underside of bridges. The research was directed to consider this problem first because such arrangement permits relatively rapid implementation, and the routine inspection provides valuable information for further research as well as clarifies the needs.

Further objectives were to evaluate the equipment for underwater use. The equipment must be capable of detecting scours conditions, spalling of concrete, deterioration of piling and cracks in steel, concrete and timber.

The originally proposed equipment complex was designed to fulfill multiple purposes and is shown by Figure 1 and 2. The shaded items are those which were evaluated in the project.

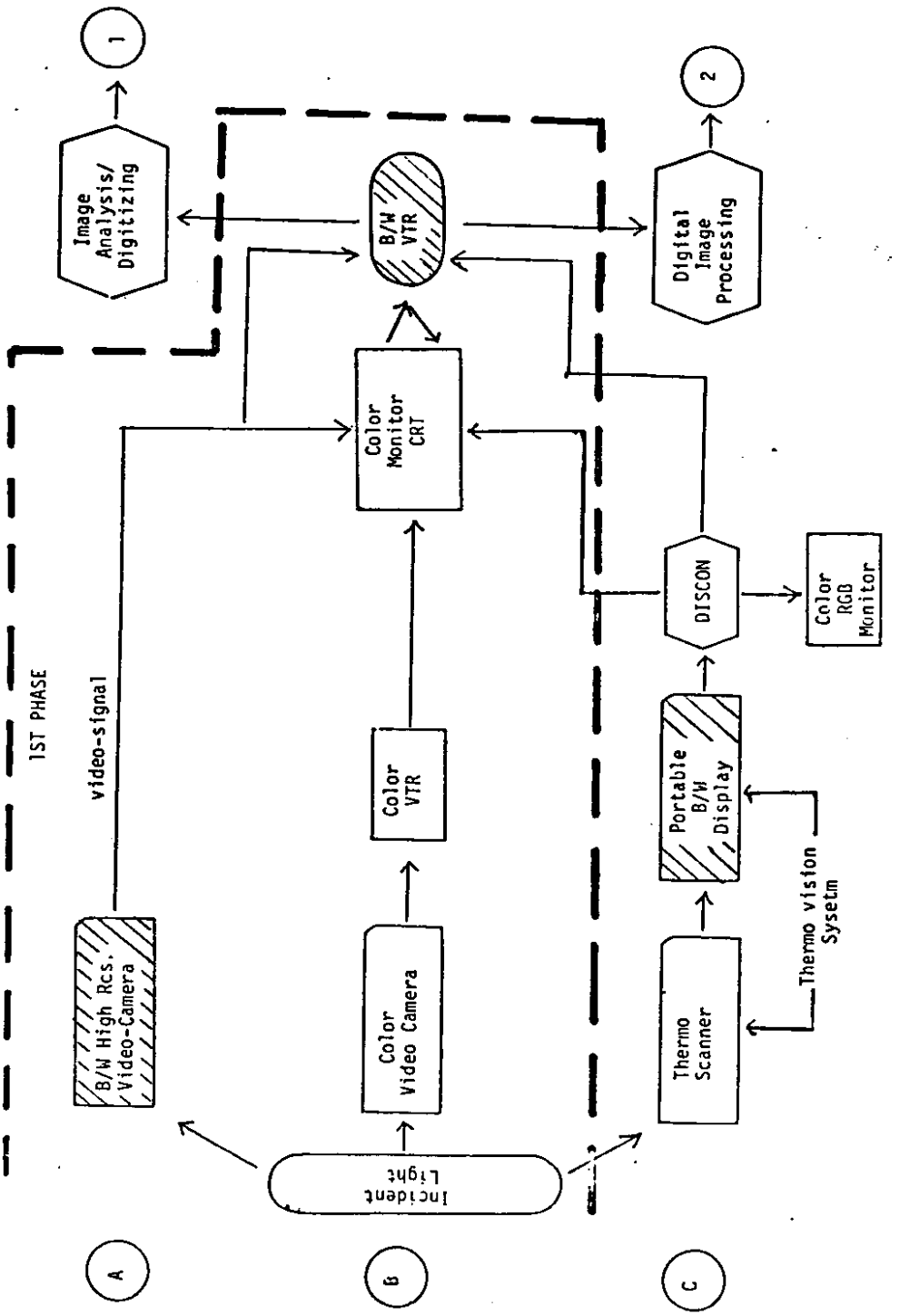
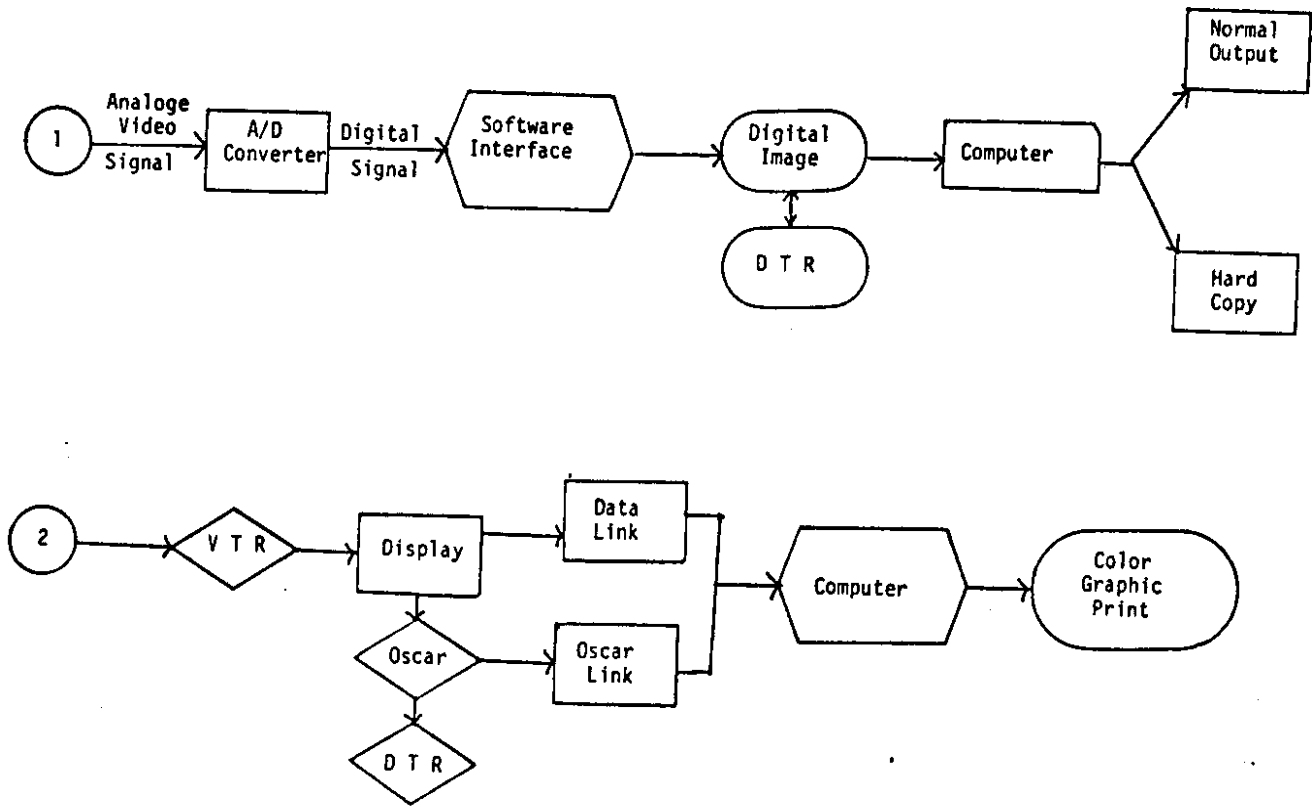


Figure 1 Scheme of the System

Figure 2 Scheme of the System (con't)



2. Equipment

The equipment is the very minimum that is needed to provide a recording system and consists of video camera, video-tape recorder and a monitor.

2.1 Video Camera

The video camera is a Panasonic WV-1900 camera and powered by 120 volts AC. The camera is equipped with Fujinon TV Zoom lens with an f. stop of 1.8. The focal length is remotely variable from 16 to 160 mm.

The lens mount is a so-called "C" mount, thus a variety of other lenses are available for the camera. Unfortunately, the Fujinon zoom lens with the built-in adjusting motor is so heavy that the connection between the lens and the camera must have been reenforced, which was accomplished in the machine shop of the University of Washington. Further, a handle was attached to this reinforcement for convenient transportation.

The camera capable to provide usable pictures under extremely low illumination levels is a minimum 3×10^{-4} footcandle is required. This means it is possible to obtain technically satisfactory pictures at night time or from structural components in deep shadows.

The camera is equipped with built-in projection circuit for the video tube and image intensifier. The lens iris control is automatic. The camera contrast balancing system is rather slow, and unable to balance large illumination differences.

Technically, the best picture obtained under overcast or heavy overcast skys. This should be imposed on the use of the camera.

The camera specification indicates that "Generally the greater the object illumination the higher will be the resulting picture quality" proved incorrect in the practice. Aiming the camera is obtained through the observation of the monitor. This form of picture taking is difficult and slow. As a consequence, it is recommended that a "gunsight" type of aiming device be constructed which incorporates the picture framing for easier operation.

The detailed technical description and the technical data are included in the appendix.

2.2 Video-Recorder and Monitor

The video recorder is a Panasonic NV-9240XD recorder. Power requirements is 120 volts and 130 watts, AC. The video tape recorder requires 3/4 inch high resolution tape. The video tape recorder is equipped with two channel audio recording.

The audio recording was not utilized in this research, however, it is recommended that in the routine use to be utilized for identification of certain parts of the structure and for voice description and data storage from the structure.

The monitor utilized is a 19" Black and White monitor. The resolution of the monitor is 960 TV lines as compared to the conventional 525 TV lines monitors. There are a maximum of 1025 TV lines monitors available on the market. The 960 TV lines resolution proved to be completely adequate. For higher resolution one may select the 1025 lines in the future.

The monitor required 120 volts power supply.

3. Resolution Test

The resolution test for the video camera was designed in similar fashion to that of conventional photographic cameras. This enables the user to compare the results to that of conventional cameras. Thus, the utilization of the video equipment as compared to photographic equipment can be based on laboratory fact.

3.1 Day and Night Resolution

In order to determine the resolution of the camera and monitor, and the camera video-tape recorder and the monitor combination, the standard black and white resolution targets were used.

The concept of the test is to produce a target (a plywood panel) composed of black and white bars and read the resolution under various conditions.

The scale of target is designed for 1/600, i.e. if the distance between the center of two white bars is 6 cm, then the resolution of this is

$$\frac{1}{60\text{mm/line} \times 1/600} = 10 \text{ lines/mm}$$ as shown by Figure 3

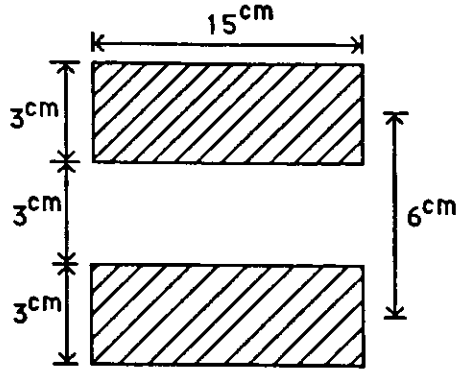


Figure 3 Target design

Calculations of the distances between camera and target using different focal lengths.

A) for f = 16 mm

scale = 1/600

f/d = scale

16 mm/D = 1/600

D = 9600 mm = 9.6 m

where D is the photographic distance

B) for f = 160 mm

160/D = 1/600

D = 96 m

The resolution pattern for f = 160 mm is as follows:

The target is located at the center of the picture:

Day time resolution is 15 lines/mm

Night time resolution is 14.5 lines/mm

The resolution is exactly the same for f = 16 mm.

The resolution remains the same, that is 17.5 lines/mm for the f = 160 mm in the entire screen area. It was tested so that the target occupied the upper left and right corner and the lower left and right corner of the screen of the monitor. The resolution, however, deteriorates if f = 16 mm is used. It reduces to 15 lines/mm at the corners.

There were no resolution differences if the camera and monitor combination were used or camera-video tape recorder and monitor combination were used.

During this test there were additional problems detected. The ability of the photo-cathode recording tube to balance contrast is limited. This fact is indicated by the higher resolution at night time.

The ideal use of the camera, therefore, is when the contrast is

minimum, such as under overcast skys, and in uniform shadows.

The construction of the lens is such that it has considerable reflecting surfaces. The light reflected from these surfaces can "wash out" the pictures, thus making it technically useless. This can be improved by proper selection of the direction of photography. The camera is particularly sensitive when it is used against the light.

3.2 Contrast Test

The limited contrast balancing capability of the camera made it necessary to perform a contrast test. The contrast test was performed somewhat the same way as the resolution test. The photographic distance, however, was fixed at 10 meters (30 feet about). Separate targets were selected for the 16 mm and 160 mm focal length. The target composed of horizontal and vertical bars and their size was 12" x 12". The colors were black on orange background. The black bars were in four different tones (indian ink, dark, medium, light) and the white bars in black background.

The target was designed for 20, 30 and 40 lines/mm is used in the following way:

When f = 16 mm, scale = f/d = 16/10,000

line/mm		
20	(1/40 mm/line)(10,000/16)	= 15.62 mm (width) = 78.12 mm (length)
30	(1/60)(10,000/16)	= 10.42 mm (width) = 52.08 mm (length)
40	(1/80)(10,000/16)	= 7.81 mm (width) = 39.06 mm (length)

When f = 160 mm is used. scale = f/d = 160/10,000

line/mm		
20	(1/40)(10,000/160)	= 1.56 mm (width) = 7.81 mm (length)
30	(1/60)(10,000/160)	= 1.04 mm (width) = 5.21 mm (length)
40	(1/80)(10,000/160)	= 0.78 mm (width) = 3.91 mm (length)

The result proved the indications obtained during the resolution test. That is the lens at 160 mm focal length able to resolve up to 30 lines/mm with the orange and black (ink) colors and 20 lines/mm for f = 16 mm. When a high contrast such as black and white is used the lens was not able to resolve the target.

Therefore, the camera may be used effectively for low-contrast subject. This conclusion indicates that the camera is well suited for inspection of concrete bridges; particularly at the low illumination level.

3.3 Detectable Crack Width

To determine the limitations of the camera in detecting cracks, certain tests were executed. The tests were particularly designed to obtain the minimum detectable width of a crack.

The focal length was varied and tested at the extremes of f = 16 mm and f = 160 mm.

The distance from the target was also varied. These tests were made at 10 ft, 20 ft, and 30 ft.

The targets were with a precisely measured black line on orange and white background.

The illumination also influences the minimum detectable crack width considerably. The test were made in laboratory conditions, that is, the room had a fluorescent illumination. The tests were made in fully illuminated laboratory and in the dark with the lights turned off, the results are summarized in the following table:

distance	target color	focal length	minimum detectable crack width in mm	
			with light on	with light off
10 ft	orange	16	1.0	1.0
10 ft	orange	160	0.1	0.5
10 ft	white	16	1.0	1.0
10 ft	white	160	0.1	0.1
20 ft	orange	16	1.0	1.0
20 ft	orange	160	0.1	0.5
20 ft	white	16	1.0	1.0
20 ft	white	160	0.3	0.5
30 ft	orange	16	1.0	1.0
30 ft	orange	160	0.1	1.0
30 ft	white	16	1.0	1.0
30 ft	white	160	0.5	0.5

Table 1 Minimum Detectable Crack Width

In summary, the longer focal length provided the better the results, as was expected. The results also were better in the illuminated laboratory than in the dark, a clear indication that the illumination increases the contrast. This fact was also indicated by the difference between the illumination levels. It was smaller in case of white background because of the higher contrast of the target.

4. Water Penetration Tests

One of the least accessable areas of any structure is the part which is located under water. This is one of the most critical parts of the inspection because there are so many variables involved. This is reflected by the fact that the most elaborate test were executed in this field.

The experiments were performed in the Harris Hydraulics Laboratory where a 50 foot long 2x2 ft water tank was available. The experiment procedure was such that two basic categories were used; one against the flow and one with the flow. The geometry, which will be called "Against the Flow" was arranged in such a way that the camera was facing the wave generator; and the target was between the two. The geometry "with the flow" was such that the wave generator was behind, and the target was in the front of the camera. Each of these set ups were subjected to 240 different conditionings by using five levels of turbulence, four levels of suspended particles in the water, four different illumination conditions and at three different distances between the camera and the targets.

These experiments were then repeated three times: camera without filter, camera with ultraviolet filter on it and camera with infrared filter. These experiments were then evaluated in form of graphs and the graphs were analyzed, and interpreted. These graphs, because of voluminous nature will

be omitted from this final technical report.

4.1 Water Penetration

The general arrangement of the test is shown by figure 4, with and against the flow.

A floating container was fabricated from 1/4 inch thick plexiglass. A portion of the floating container was replaced by optical glass to eliminate the undersirable optical characteristics of the plexiglass. The size of the container is one foot wide and two feet high, with three feet length. The floating container was submerged in the water by one foot. To keep the container submerged the weight of the container must exactly equal the weight of the displaced water.

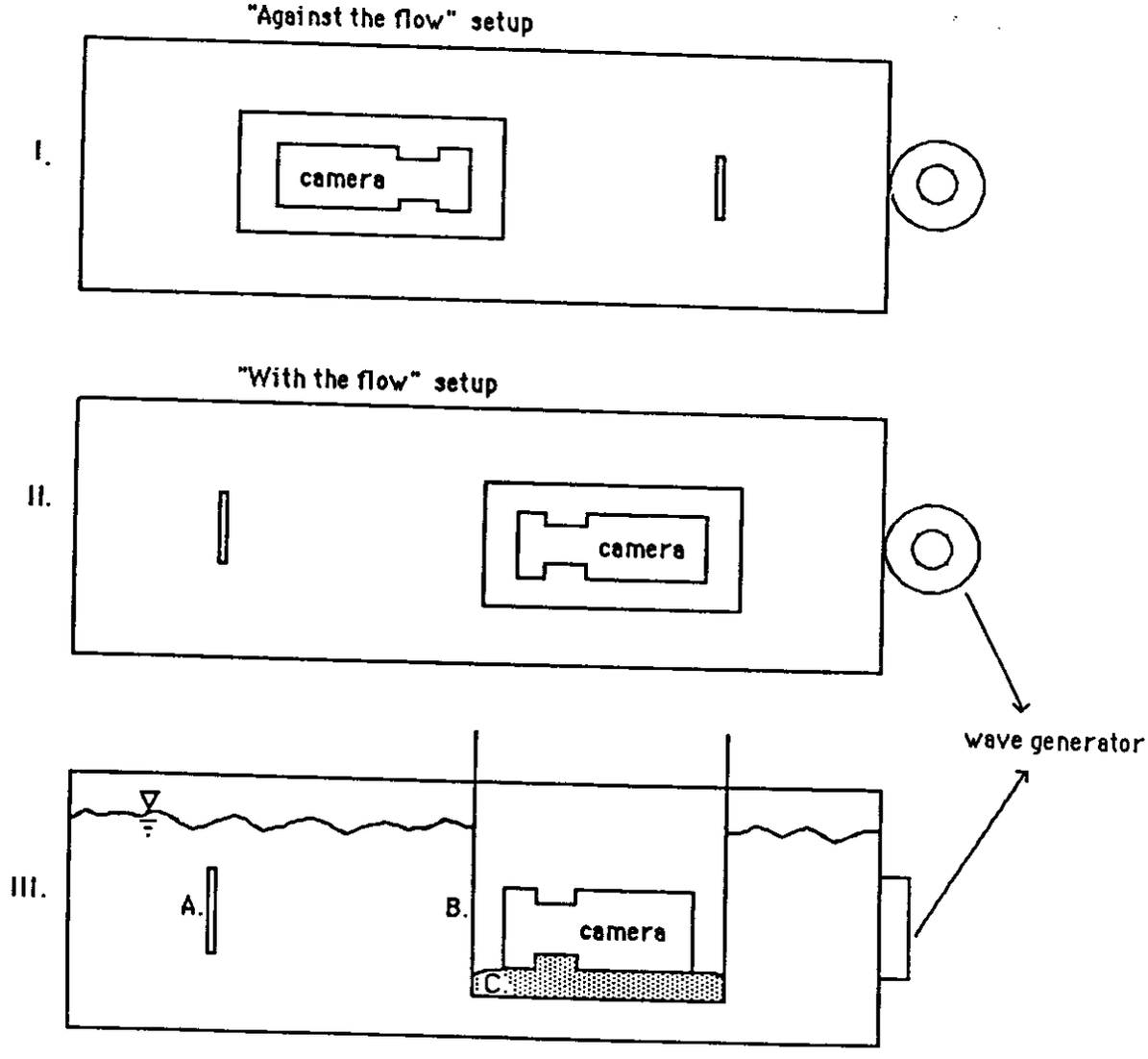
The following equation were used to determine the weight required for ballast: (volume of container) . $\{\gamma$ (container + camera + sandbag)$\} = \gamma \cdot$ (volume of water). Where γ is the specific gravity. Substituting the numerical values into this equation and using 12 pounds for the camera, the required sandbag was 145 pounds. This was placed into the container to keep it submerged.

This video system was tested under various turbidity. Kaolinite was added to water in the wave tank in order to achieve different concentration. The concentration was measured in mg/l .

The water tank holds 2390 liter of water. Five different concentrations were used: zero concentration or tap water, 1.0 mg/l, 2 mg/l, 3 mg/l and 6 mg/l.

The target for the penetration test was constructed. The target was very similar to the panels used to determine the resolution for the camera in

Lab Setup



A. Target (see TARGETS FOR PENETRATION TEST for detail)

B. Container (see PLEXIGLAS CONTAINER for detail.)

C. Sandbag to counter balance for buoyancy force. (see FLOATING CONTAINER for detail)

Figure 4 Test arrangement.

the day and night time illumination. It was constructed from a panel of plywood; and there were 2 inches in diameter holes for allowing the possibility of use in waves. The width and length of the white bars on black background were computed and it is given in Table 2.

The results of these experiments are summarized in Table 3 for day time measurement and in Table 4 for night time measurement.

The resolution "with the flow" (W) is consistently better than "against the flow" (A). This statement applies only for day time observations and does not apply to night time observation. For night time observation the resolution is the same for both conditions (A&W). The differences between A and B do not increase with the increasing turbulence.

Turbulence was generated by the wave generator at 0 cycle/m/10, 300 cycle/m/10, 600 cycle/m/10 and 900 cycle/m/10. The turbulence has no effect "with the flow", however, when "against the flow" set up was used the resolution decreased with the increased turbulence.

Turbidity is the major influencing factor for the resolution. The resolution drastically decreased as the turbidity increased. The maximum turbidity is about 4. mg/l above that the video system cannot be used for underwater structural inspection.

The position and kind of illumination has a limited effect on the resolution. Natural light (i.e,. sunlight coming through windows) gave higher resolution than artificial light did. The best position for illumination is when the light is located directly above the camera. If the light is on left or right side of the camera a considerable amount of light scattering occurs which reduces the resolution. This indicates that the underwater inspection should take place at high sun angles that is, in the summer time and at noon hours.

Table 2

TARGETS FOR PENETRATION TEST

For f = 16 mm Resolution	bar size (mm/line) width / length		
	D = 1m	D = 2m	D = 4m
10.0 line/mm	3.12 mm/line	6.25	12.50
	15.62	31.25	62.50
12.5	2.50	5.00	10.00
	12.50	25.00	50.00
15.0	2.08	4.17	8.33
	10.42	20.83	41.67
17.5	1.78	3.57	7.14
	8.93	17.86	35.71
20.0	1.56	3.12	6.25
	7.81	15.62	31.25
22.5	1.39	2.78	5.56
	6.94	13.89	27.78
25.0	1.25	2.50	5.00
	6.25	12.50	25.00
27.5	1.14	2.27	4.54
	5.68	11.36	22.73
30.0	1.04	2.08	4.17
	5.21	10.42	20.83
32.5	0.96	1.92	3.85
	4.81	9.62	19.23
35.0	0.89	1.78	3.57
	4.46	8.93	17.86

TABLE 3

SUMMARY TABLE FOR WATER PENETRATION TEST (daytime, in Harris Hydraulics Lab)

Resolution in lines/mm

Turbidity / Direction of camera / Illumination condition / Distance / Turbulence		Tap water				1.0 mg/l				3.0 mg/l				6 mg/l			
		W		A		W		A		W		A		W		A	
		N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR
0	1 m	20.0		20.0		19	17.5	17.5	17.5	15	15	15	15	8.5	7.5	7.5	7.0
	2	17.5		15.0													
	3	15.0		12.5													
300 cycle/m / 10	1	17.5		17.5		17.5	17.5	15.0	17.5	16	15	15	15.5	8.5	7.5	7.0	5.0
	2	12.5		12.5													
	3	12.5		10.0													
600 cycle/m / 10	1	17.5		17.5		17.5	17.5	15.0	16.0	16.0	15	12.5	12.5	8.5	6.5	5.0	5.0
	2	12.5		12.5													
	3	10.0		10.0													
900 cycle/m / 10	1	15.0		15.0		20.0	17.5	15.0	15.0	16.0	15.0	11.0	11.0	7.0	6.0	5.0	5.0
	2	12.5		12.5													
	3	10.0		10.0													

Table 4

SUMMARY TABLE FOR WATER PENETRATION TEST (Nighttime, in Harris Hydraulics Lab)

Resolution in lines/mm

Turbidity / Direction of camera / Illumination condition / Distance / Turbulence		Tap Water				1.0 mg/l				2.0 mg/l				3.0 mg/l			
		W		A		W		A		W		A		W		A	
		L	R	L	R	L	R	L	R	L	R	L	R	L	R		
0	1	15.0	17.5	17.5	20.0	17.5	20.0	17.5	20.0	12.5	15.0	17.5	15.0	5.0	6.0	5.0	6.0
	2	12.5	15.0	10.0	10.0	12.5	12.5	12.5	12.5								
300 cycle/m / 10	1	12.5	12.5	15.0	17.5	17.5	17.5	17.5	17.5	10.0	10.0	15.0	15.0	6.0	8.0	7.0	7.0
	2	10.0	12.5	10.0	12.5	11.0	11.0										
600 cycle/m / 10	1	12.5	12.5	15.0	16.0	15.0	17.5	15.0	16.0	10.0	10.0	12.5	12.5	10.0	10.0	6.0	7.0
	2	10.0	10.0	10.0	12.5	7.5	7.5										
900 cycle/m / 10	1	12.5	15.0	15.0	17.5	17.5	17.5	12.5	15.0	10.0	10.0	12.5	12.5	8.0	7.0	5.0	6.0
	2	7.5	10.0	10.0	12.5												

SUMMARY TABLE FOR ULTRA VIOLET CAPABILITY TEST (Daytime, in Harris Hydraulics Lab)

Resolution in lines/mm

Turbulence	Dist.	Turbidity	Tap Water				0.5 mg Kaolin/1 water				1.0 mg Kaolin/1 water				2.0 mg Kaolin/1 water				3.0 mg Kaolin/1 water				5.0 mg Kaolin/1wate			
		Weather Cond.	CLOUDY				SUNNY				PARTIALLY SUNNY				CLOUDY				CLOUDY				CLOUDY			
		Dir. of Camera	W		A		W		A		W		A		W		A		W		A		W		A	
		Illum. Cond.	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR
0	1 m		9.0	15.0	6.2	16.0	5.5	17.0	15.0	16.0	9.0	15.0	12.5	17.0	7.5	14.0	5.0	14.0	7.0	14.5	7.0	14.0	3.0	12.0	6.3	11.5
	2 m		8.0	12.5		10.0	4.0	11.0	10.0	14.0		12.5		12.5		8.0		10.0		7.5	4.0	7.5				1.0
	3 m									7.0				9.0												
300cycles/m 10	1 m		7.0	15.0	6.0	15.0	6.5	15.0	12.5	16.0	7.0	15.0	9.0	17.0	5.5	14.5	5.0	13.0	6.0	14.0	6.0	14.5	2.5	11.0	6.0	11.0
	2 m		5.0	10.0		12.5	5.0	11.0	6.5	12.0		12.5		13.0		8.0		8.0		9.0		8.5				1.0
	3 m									5.0																
600cycles/m 10	1 m		5.0	11.0	5.0	12.5	6.0	14.0	9.0	15.0	6.5	13.0	10.0	13.0	5.0	12.5	4.0	12.5	6.0	13.0	5.0	13.0	4.0	11.5	5.0	11.5
	2 m			9.5		8.0		10.0	5.0	12.5		12.5		10.0		7.5		7.5		6.0		7.0				
	3 m									3.0																
900cycles/m 10	1 m		7.0	12.5	5.0	12.5	5.0	11.0	7.5	15.0	5.0	12.5	9.0	12.5	4.5	12.0	4.0	11.5	5.5	13.0	4.5	14.0	4.5	11.0	4.0	11.5
	2 m			8.0		10.0		8.0	2.0	10.0		12.0		10.0		6.5		6.3		9.0		7.5				
	3 m																									

Table 5

SUMMARY TABLE FOR ULTRA VIOLET CAPABILITY TEST (Nighttime, in Harris Hydraulics Lab)

Resolution in lines/mm

Turbulence	Dist.	Turbidity / Dir. of Camera / Illum. Cond.	Tap Water				0.5 mg Kaolin/l water				1 mg Kaolin/ 1 water				2 mg kaolin/l water				3 mg Kaolin/l water				5 mg Kaolin/ 1 water				7 mg Kaolin/ 1 water			
			W		A		W		A		W		A		W		A		W		A		W		A		W		A	
			L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R		
0		1 m	6.3	15.0	7.5	16.0	6.3	16.0	7.5	16.0	4.5	8.5	5.0	11.0	7.0	12.5	7.5	15.0	6.0	12.5	6.0	15.0	8.5	12.0	9.0	11.0	6.5	8.5	5.5	9.0
		2 m	6.3	12.5	7.5	15.0	5.0	11.0	7.5	13.0		7.5	2.0	6.0	6.3	11.0	6.0	10.0		4.0		2.0								
		3 m		7.5		7.5		4.0																						
100cycle/m / 10		1 m	7.5	11.5	7.5	10.0	6.3	10.0	7.5	15.0	4.0	8.5	5.0	9.0	6.5	12.0	7.5	13.0	6.0	9.5	6.0	11.5	9.0	12.5	8.5	10.0	6.3	9.0	5.5	8.0
		2 m	5.0	10.0	5.0	7.0	5.0	8.0	6.3	10.0		6.0		6.0	4.0	8.0	4.0	9.0					6.0	7.5		1.0				
		3 m																												
400cycle/m / 10		1 m	6.3	12.5	4.0	7.5	5.0	9.0	7.5	14.0	4.0	8.0	4.5	10.0	6.5	10.0	6.0	11.0	5.5	8.5	5.0	11.0	8.5	11.0	7.0	10.0	6.5	8.5	4.0	8.5
		2 m	5.0	10.0		6.3	2.0	7.7	6.3	12.5		5.0		6.0	2.0	7.5	2.5	8.0					6.0	6.0		6.0				
		3 m																												
900cycle/m / 10		1 m	6.3	10.0	5.0	7.5	4.5	9.0	7.5	13.0	4.0	6.3	4.0	8.0	6.0	9.0	6.0	10.0	6.0	8.5	5.5	9.0					5.0	9.0	2.0	7.7
		2 m	5.0	7.5		6.3		7.5	5.0	11.0		2.0		6.0		7.5		7.5					2.0	7.0		2.0				
		3 m																												

Table 6

4.2 U.V. Water Penetration

The water penetration experiments clearly indicated that the resolution, along with the observation distance, rapidly decreased with the increased turbidity. This is mostly the result of light scattering. The suspended particles in the water scatter the light, as a consequence, the obscure the target. The amount of light scattering is different in various wave lengths. In the blue region more scattering occurs than in the red region. Therefore, these two wave lengths were investigated.

The experiments was about the same as described in the previous section.

These experiments summarized in Table 5 and Table 6 for the day time and night time measurements.

There were no detectable differences between "With the Flow" and "Against the Flow" configuration.

The effect of turbulence is relatively small; the resolution decreases as the turbulence is increased. The major benefit of the U.V. filter is shown for the turbidity. The resolution did not decrease as drastically with the increase of turbidity as it did without the filter. This is a clear indication that the light scattering is one of the major influencing factors in water penetration.

4.3 I.R. Water Penetration

As it was mentioned in the previous section, only 20 percent of the light with the wave length of red will scatter. In order to investigate this phenomena, an Infra-red filter was placed in the front of the camera lens to utilize this radiation to the maximum extent.

The experiments in general was conducted in the same manner as

previously described for the U.V. filter. The results are summarized in Table 7 for day time observations and in Table 8 for night time observation.

Most resolutions are better "With the Flow" than "Against the Flow", however, this pattern is not consistent. In this experiment, most night time resolutions are better than the day time resolutions. This phenomena is due to the illumination. The illumination is one of the major parameters which influences the resolution. The best is to illuminate the object from above. This is the case in nature, therefore, it can be expected that the resolution will be somewhat better in natural circumstances than in the laboratory.

If one compares the Tables 3 to 8, one will find that the use of filters either U.V. or I.R. is mandatory in underwater video recording. The major influencing factor, in reduction of resolution is the turbidity. If, however, the filter is used this influence is drastically reduced. For example, in the case of infrared filter in day time measurement, Table 7 at zero turbidity, there are 17 lines/mm natural and artificial illumination. When the turbidity is 5 mg/l the resolution is 12.5 lines/mm. These results can be compared to Table 3 where the resolutions are 20 lines/mm and 7 lines/mm respectively.

4.4 Test at Lake Washington

In order to verify the laboratory findings the resolution tests were performed under natural conditions. Lake Washington was selected for this purpose. The site is located north of the Evergreen Point Bridge at the northeast end of Fosters Island. The experiments were made from boat and water samples were collected to determine the turbidity.

The water penetration test was made under two different illuminations,

at three different sites and two different geometrical positions.

Tests were made in sunshine and under the shade of the Evergreen Point Bridge. Two different sites were chosen north of the bridge with different turbidity which changed from 1.0 to 8.2 under the bridge. Tests were made horizontally and vertically. Both with the focal length of f = 160 mm.

At site one under sunshine, the resolution found 22.5 lines/mm at 1 m distance, 15 lines/mm at 2 m distance and 0 lines/mm. at 3 m distance. At site two the resolution found 15 lines/mm at 1m distance and 0 lines/mm at 2 m distance. The above tests were made horizontally.

The test under the shade of the bridge were made vertically with the water turbidity of 8.2. The resolution at 2 m was 12.5 lines/mm.

This test proved the illumination in general is one of the main contributors to the resolution. If one compares the above results to those which were obtained in the laboratories one can find that the natural light provides a better result. The reflection of sunshine in the water particularly at horizontal camera position, creates considerable difficulties. This was noticeable at the number two test site where no resolution was obtained at 2 m distance because of reflection.

The final conclusion of these test is the system can be used for under water inspection.

5. Application of U.V. and I.R. Filters

The wave length response of the photo-cathode video recording tube is shown by Figure 4. The characteristic shows a relatively stable response in the variable wave length (450-400 nm). The sensitivity continues, beyond the visible spectrum, particularly toward the ultraviolet wave length. This

indicates that with proper filtering this wave length may be utilized.

INFRARED (Daytime)
Resolution in lines/mm

Turbidity / Dir. of Camera / Illum. Cond. / Dist. / Turbulence		Tap Water				1.0 mg/l				2.0 mg/l				3.0 mg/l				5.0 mg/l			
		W		A		W		A		W		A		W		A		W		A	
		N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR	N	NR
0	1	8.5	17.0	13.0	17.0	7.5	16.5	14.5	18.0	7.0	17.5	10.0	15.5	10.0	17.5	13.0	17.0	12.0	13.0	8.2	12.5
	2	6.5	12.5	10.0	15.0	6.0	9.5	9.0	13.5		7.5	5.5	7.2	6.5	8.5	5.0	6.5				
	3				10.0																
300	1	6.25	16.5	11.0	16.5	8.0	15.5	12.5	17.5	6.5	15.0	8.5	15.0	10.0	17.5	12.5	16.0	9.0	13.0	7.5	12.0
	2	4.50	12.0	8.0	13.0	5.0	10.0	8.3	12.5		7.0	5.0	7.5	6.0	7.5	6.5	7.5				
	3				5.0																
600	1	6.70	12.5	10.0	16.0	7.5	15.0	10.0	17.0	6.5	14.0	8.0	14.3	9.0	16.5	11.5	15.5	9.0	12.5	8.0	12.5
	2	3.00	7.0	5.0	12.5	4.0	11.0	7.5	12.0		6.0		6.3	4.5	7.5	4.5	7.0				
	3																				
900	1	4.50	9.5	12.0	14.0	6.3	13.5	9.0	15.0	6.5	14.5	6.5	12.5	9.5	17.0	10.5	15.0	8.0	12.5	7.8	12.0
	2		9.0	6.0	9.5	4.5	9.5	6.5	9.5		7.5		5.0		7.5		6.5				
	3																				

Table 7

INFRARED (Nightime)

Turbidity / Dir. of Camera / Illum. Cond. / Dist. / Turbulence		Tap Water				1.0 mg/l				2.0 mg/l				3.0 mg/l				5.0 mg/l				7.0 mg/l			
		W		A		W		A		W		A		W		A		W		A		W		A	
		L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
0	1	6.25	13.0	6.5	16.5	6.3	12.5	5.0	12.0	9.0	16.0	9.0	15.5	9.0	14.0	6.5	13.0	8.8	12.0	9.0	14.0	7.0	8.0	6.3	8.[illegible]
	2	6.00	12.5	6.25	13.0	6.3	5.0		7.0	7.5	8.0	5.5	6.0												
	3		7.5		9.0																				
300	1	6.25	12.0	6.0	14.0	6.3	13.0	5.0	10.0	8.5	14.0	8.0	15.0	9.0	14.0	6.5	12.0	7.5	11.5	9.5	13.5	7.0	8.5	8.0	9.5
	2	4.25	12.0	6.25	10.0	1.0	8.0		6.3	7.0	7.5		7.5												
	3																								
600	1	6.0	11.0	6.0	12.0	6.3	10.0	4.5	10.0	8.0	13.5	7.0	13.5	7.5	12.5	6.5	11.0	7.0	11.0	9.8	13.0	6.5	8.8	7.0	9.0
	2	4.0	10.0	5.0	10.5		7.5		7.5	5.5	7.5	4.0	7.5												
	3																								
900	1	6.0	11.0	5.0	10.0	6.0	10.0	4.5	9.0	7.5	12.5	8.5	12.5	7.5	12.0	6.0	10.5	7.5	11.5	9.6	12.5	6.0	9.0	7.0	8.7
	2	3.0	8.75	3.0	7.0		6.3		6.0		7.5		5.0												
	3																								

Table 8

5.1 Ultraviolet Filter

The reflection of the visible spectrum from various materials is dependent on the wavelength and on the material. This property permits the use of filters, to judge the condition of the examined structure. For example, rust underneath the paint, which is not visible to the naked eye,may be visible using ultraviolet filter and/or ultraviolet illumination.

An ultraviolet filter was obtained with characteristics shown by Figure 6. The filter has nearly 100 percent transmittance at blue or shorter than 450 n.m. wavelength. Therefore, the image is formed mostly from the reflected ultra violet lights.

A rust test has been performed to see the effectiveness of the ultraviolet filter and/or ultraviolet illumination.

A number of steel specimens were selected at various stages of rusting. All were painted over with gray color enamel paint. Then video-tape was made from these specimens.

The results of these rust tests are summaraized in Table 9

Filter	Light Source	Detecting Rusted Steel
None	Natural Ultra violet Infrared	Fair Good No Detection
Ultra Violet	Natural Ultra Violet Infrared	Good Very Good Fair
Infrared	Natural Ultraviolet Infrared	No Detection No Detection No Detection

Table 9 Rust Test Results

The specimens were illuminated by natural light, ultraviolet and by infrared light. As the table shows, the photo-cathode tube is able to register the ultra violet reflections and a certain detection can be accomplished. The best detection is when ultraviolet filters is used in connection with ultraviolet illumination.

It can be concluded from this test that ultraviolet filters should be used in the practice for inspection of steel bridges.

5.2 Infrared Filter

In principle, similar experiments were performed with infrared filters for different purposes.

The maximum advantage of the infrared radiation for bridge inspection would be around the 1000(nm) wave length or in the heat wave region. This region is ideal for detection of concrete lamination of bridge decks. The concrete lamination is detectable by their temperature difference as compared to the solid concrete. In one analysis the characteristics of the photo-cathode tube (Figure 5), it can be seen that it is rapidly falling after the 900 nm. In spite of this, tests were made for experimental evaluation of the infrared image formation. The camera was equipped with an infrared filter. The characteristic of the filter is shown by Figure 7. The filter transmits only a limited amount of light at shorter than 700 (nm) wave lengths and transmits nearly 100 percent over 700 nm wave length. This insures that the image is formed by infrared rays.

Various metallic materials such as aluminum, steel and non-metallic# material such as concrete and bricks was heated to obtain the temperature differences up to 20 degrees of centigrade. Video tapes were made from these objects.

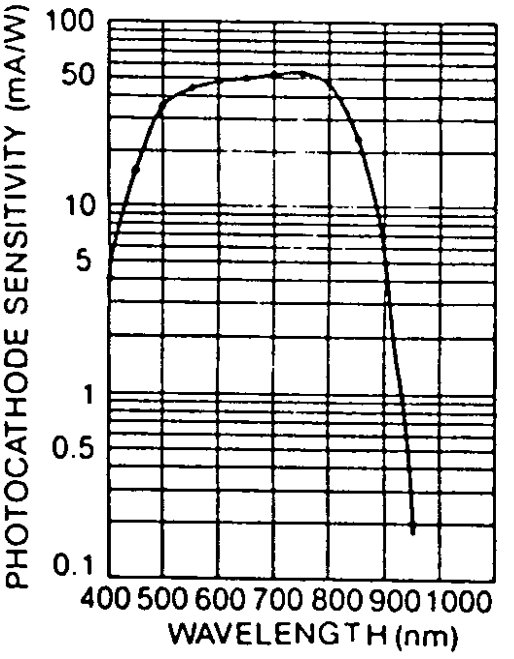


Fig 5 Photocathode Sensitivity

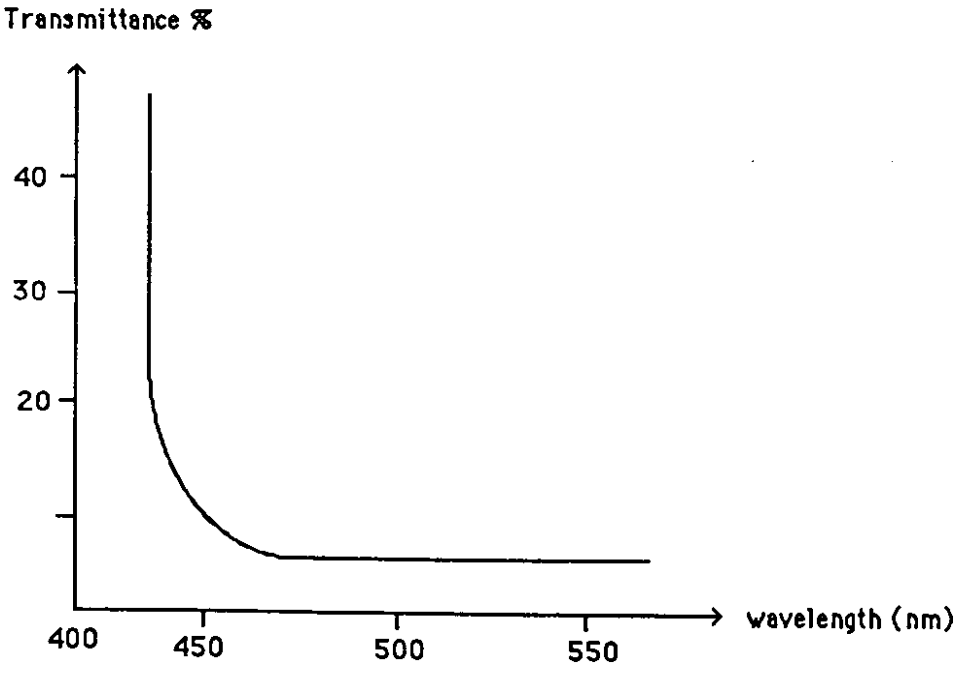


Figure 6 Ultraviolet Filter

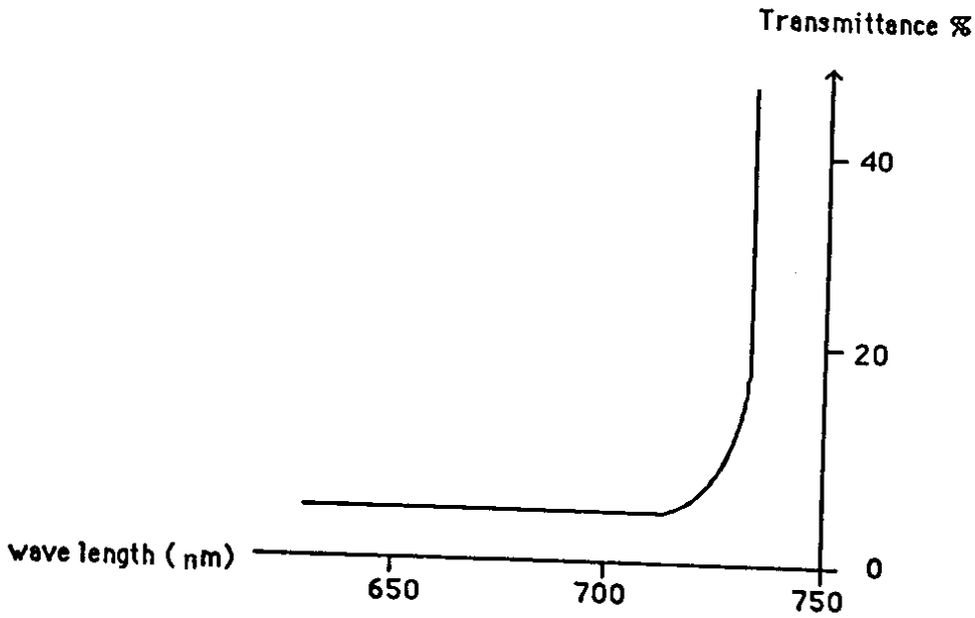


Figure 7 Infrared filter

This test showed no difference in tone among the various materials with different temperature levels. This means that this video system cannot be used for detection of lamination. If one desire to obtain such information a thermo-scanner must be utilized along side of this video system.

Further tests were made in connection with the detection of cracks, particularly on concrete, where the cracks have some water in them. This test proved to be positive because the water absorbed the infrared radiation. Therefore, it appears in considerable contrast as compared to the neighboring dry concrete.

6. Practical Inspection

All bridges that were usable and accessable were used along the I-90 corridor to perform the practical tests. The cracks could be reported in all cases.

The largest number of tests were made on bridge No. 90/81 N. Further, there was a steel bridge selected, which is located on the I-5 corridor bridging over the Toutle River

The major problem encountered with all these experiments is the transportation. The equipment, by size, is such that it can be packed into a family sedan. However, the family sedan will not be able to provide the semi-dark illumination which is needed for the clarity of image of the monitor. The following equipment needed to be transported is:

1. video-camera
2. tripod
3. video recorder
4. electric generator

It, therefore, is suggested that a small station wagon with darkened windows,

(or without windows) be used for this purpose. The monitor could be placed in the wagon so the semi-dark illumination can be provided.

6.1 Concrete Bridge

There were four tests executed on various concrete bridges along the I-90 corridor. All these bridges had some crack in the superstructure. One of the tests served as a demonstration to the W.S. DOT officials.

All of these tests resulted in the positive conclusion that the wide-system in general and this equipment in particular can be used for concrete bridge inspection.

Different photographic distances were used to determine the maximum usable photographic distance. There were cracks photographed from 20, 40, 60 and 150 feet distance. These experiments indicates that the maximum photographic distance with this lens (zoom f=16 mm to 160 mm) is 150 ft. At this distance the camera is able to detect cracks of about 1 mm wide.

The scanning speed and the illumination are the most influencing factors on the quality of images. The scanning speed must be very slow to have enough time to adjust the auto-focusing. It is evident from these tests that there is a certain time lag in the automatic adjustment to the light level. This further requires a very slow scanning speed. It appears to be a good practice to scan the bridge very slowly and pause at certain suspected areas to obtain the maximum resolution possible.

The iris of the lens, or the f-stop is automatically adjusted. It is adjusted in such a manner that the illumination level is measured on the entire picture area and it is adjusted to the average area illumination. This, in general, is a good feature except when the contrast on the image is

too large such as bright sunshine and deep shadows. The bright area over powers the dark areas and the details are diminished on the dark surface.

It was found that the illumination is most desirable when the weather is cloudy. The test was made under cloudy conditions providing the best quality images.

The video casette recorder is very sensitive to dust. It must be covered all the time to eliminate pictorial imperfections from the dust. The recorder generates very little heat, thus the ventilation for the relatively short recording time should be secondary.

The various structures of the bridge were recorded with infrared and ultra violet filters. The filters have neutral effects on the image. The ultra violet filters provided small improvements. Therefore, it is recommended that it should be used.

The recording time for a bridge is about one hour which can be reduced to about ½ hour in routine circumstances.

6.2 Steel Bridge

The Toutle River bridge on Interstate 5 were used for test purposes. The bridge has some cracks on the structure, along with some rusted area.

The illumination was bright sunshine and deep shadow when the structure was photographed underneath the bridge from the river bank.

The bridge was video taped with and without filter. Without filter the system can provide a means of recording cracks. The major problem involved in the monitoring is the illumination. The cracks were in the high contrast area. Thus, the same problem existed with concrete bridges. When the camera was moved to a position when the illumination was more even, a good quality image was obtained. The crack could be recorded. The same area was video

recorded with ultraviolet filters. The ultraviolet filter definitely improved the image quality. The crack can be distinguished more clearly. The rusty area is precisely outlined and recorded. Further, not only the rusted area but also the quality of the paint clearly distinguished. As a consequence, it is recommended that U.V. filter should be used to inspect steel bridges.

6.3 Determining the Length of Cracks

In order to obtain quantitative fidelity of the video images certain tests were made. A control board was constructed which has thirty-three points on it. The distances between points were precisely measured by physical means so that this board could be used for comparison between distances obtained by measurement of the video image and by the physical measurement.

The video images were recorded from 30 feet distance. The image was digitized from the monitor with the least reading of 12 micrometres. (It can be pointed out here that this digital information can be obtained from the video tape directly which is considerably faster but it will need additional hardware).

A general affine transformation was used to determine the distances among the points. That is:

$$x = ax' + by' + c$$
$$y = dx' + ey' + d \qquad (1)$$

where x,y are the monitor coordinates, $x'y'$ are the board coordinates, a, b,

d, e are the affine transformational coefficients and c and f are the translational elements. Nine points on the board were used to compute the a, b, c, d, e and f unknowns. Least-squares adjustments were used. The observation equations for point i are

$$v_i = a\,x_i' + by_i' + c - x_i$$

$$V_{ii} = dx'_i + ey'_i + f - y_i$$

or in matrix form:

$$V = AX - L \tag{2}$$

where A is the known coefficient matrix composed of x_i, y_i's. X is the unknown matrix and L is the vector of measured values that is the monitor coordinates. The unknowns were computed from the normal equation. That is:

$$X = (A^TA)^{-1}A^TL \tag{3}$$

knowing the transformation coefficients, the board coordinates can then be computed from the following equation for all the points

$$y' = \frac{d(x - c) + a(f - y)}{b.d - a.e}$$

$$x' = \frac{e(c - x) + b(y - f)}{b.d - a.e} \tag{4}$$

After all board coordinates were computed, the distances between points were calculated and the residuals are listed in the following table.

DISTANCE	RESIDUAL (in milimeters)
1	2.9
2	2.1
3	1.9
4	3.1
5	-1.5
6	5.6
7	27.76
8	20.00
9	27.71
10	-0.8
11	-0.7
12	5.9

Table 10. Distance Residual

Most of the residuals have positive signs which indicate that some systemmatic error is present in the system. Further, these are three large residuals which are located on the right side of the monitor in a horizontal direction, indicating that this is a monitor distortion and not on the video tape.

In conclusion, it is possible to determine the length of a crack if a control system or known dimension is located in the picture. The achievable accurancy is about ± 5 mm.

7. REFERENCES

1. Burner, A.W., W.L. Snow and W.K. Goad. "Close-Range Photogrammetry with Video Camera," Technical Papers, 51st Annual Meeting, March 10-15, 1985, p 62-77.

2. "Electrical Performance Standards for Director View High Resolution Monochrome Closed Circuit," Television Monitors--EIA Standard RS-412-A, Electronic Industries Association, October 1974.

3. "Electrical Performance Standards for Monochrome Closed Circuit Television Cameras 525/60 - Random Interlace --IEA Standard RS-420, Electronic Industries Association, January 1975.

4. "IEEE Standard on Video Signal Transmission Measurement of Linear Waveform Distortion," The Institute of Electrical and Electronics Engineers, Inc. 1979.

5. "IRE Standards on Video Techniques: Measurement of Resolution of Camera Systems, 1961," Proceedings of the IRE, Vol. 49, No. 2, March, 1961.

6. King, D., J. Vleek, S. Shemilt, "A Video Camera System for Multispectral Sensing," Technical Papers, 51st Annual Meeting, March 10-15, 1985, p 661-664.

7. Wong, K.W., E.V. Gamble, R.E. Riggins, "Analysis of RBV Television System," Photogrammetry Engineering, p 851-861, 1973.

8. Wong, K.W., "Fidelity of Space TV," Photogrammetry Engineering, May, 1970, p491-497.

9. Wong, K.W., E.V. Gamble, R.E. Riggins, "Geometric Analysis of the RBV Television System," Civil Engineering Studies, Photogrammetric Series, University of Illinois at Urbana-Champion, 1971, No. 33.

10. Wong, K.W., "Geometric Analysis of the RBV Television System --Phase V," Civil Engineering Series, Photogrammetric Series University of Illinois at Urbana--Champion, 1972, No. 35.

11. Wong, K.W., "Geometric Calibration of Television Systems for Photogrammetric Appliations," Civil Engineering Studies, University of Illinois at Urbana--Champion, 1968, No. 16.

12. Wong, K.W. "Geometric Distortions in Television Imageries," Photogrammetry Engineering, 1969, p493-500.

13. Wong, K.W., "Geometric Fidelity of Three-Space Television Systems," Civil Engineering Studies, Photogrammetry Series, University of Illinois at Urbana--Champion, 1969, No. 25.

14. Wong, K.W., "Photogrammetric Quality of Television Pictures," Civil Engineering Studies, University of Illinois at Urbana--Champion,

1968, No. 17.

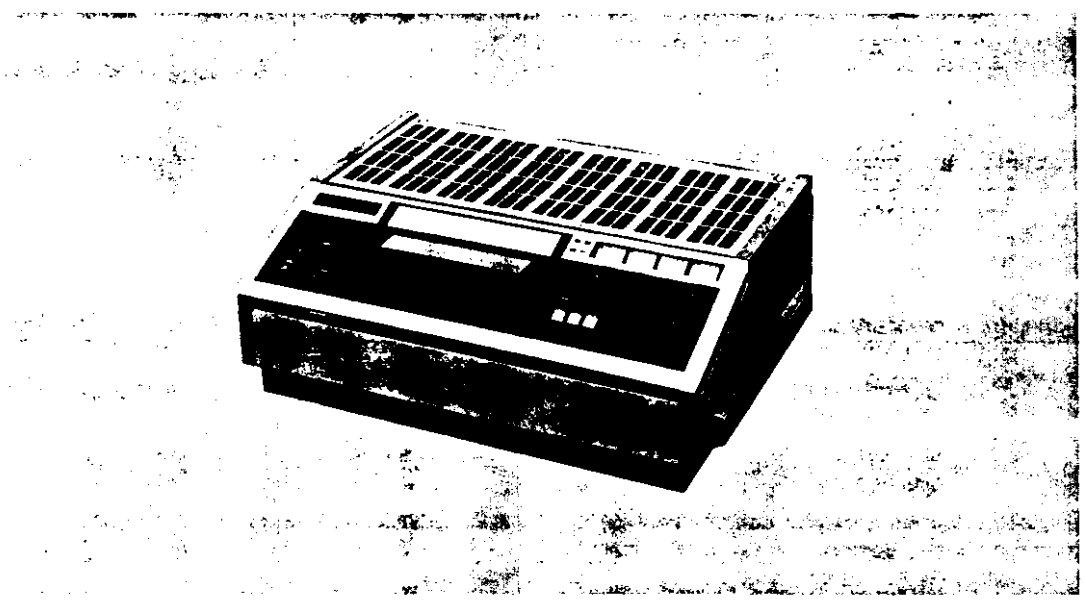
15. Wong, K.W., N.G. Yacoumelos, "Television Display of Topographic Information," Civil Engineering Studies, Photogrammetric Series University of Illinois at Urbana--Champion, 1971, No. 34.

16. Wong, K.W., Nick G. Yacoumelos, "Television Display of Topographic Maps," ACSM, Technical Papers from 31st Annual Meeting, March 7-12, 1971, p403.

Operating Instructions

Video Cassette Recorder

NV-9240XD



Panasonic

Before attempting to connect, operate or adjust this product, please read these instructions completely.

FEATURES

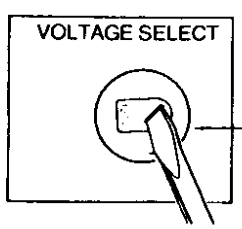
1. Direct drive video head cylinder (DDC) motor for high stability and less jitter.
2. Capstan servo system maintains precise head-to-tape speed, and allows vertical locking to an external signal.
3. Perfect frame by frame recording.
4. Mates with optional editing controller NV-A960 or auto editing controller AU-A70. (This unit can also be used with editing controller NV-A950.)
5. Connectors for recording and playback of time code on the tape track of audio CH1.
6. External composite sync input, provides vertical stability in dubbing system and for TBC* connection.
7. Subcarrier input for use with a time base corrector.
8. Convenient RF output is provided with DOC (dropout compensator) cut-off switch for connection to a time base corrector with DOC.
9. Chroma level adjustment.
10. Automatic elevator and gear driven loading systems permits simple, smooth and reliable tape loading and faultless operation.
11. Feather-touch (non-locking) push buttons with logic memory allows direct switching from one function to another, for example FF to PLAY or REW to PLAY, without first pressing the stop button.
12. 7-pin dubbing connector for dubbing.
13. With built-in dew detecting device.
14. Increased reliability due to increased use of LED display devices.
15. Optional remote control unit, NV-A152, controls record, forward, fast forward, rewind, stop, and pause (still frame).
16. Counter display reading out CTL pulse for tape counter.
17. Automatic search during rewind or fast forward by setting memory counter to "0000".
18. Automatic or manual control of video level, with video level meter.
19. Two audio tracks permit recording from two MICROPHONES, pre-amplified STEREO PHONOGRAPH, etc.
20. Two audio level meters, one for each channel.
21. Audio limiter (switchable) for low distortion recording.
22. Audio monitor output, for one or both audio channels.
23. 75Ω termination switch for video input.
24. Audio level selector for headphone.
25. Automatic phase control (APC) for stability of the color signal.
26. Comb filter and HPF™ video heads for high quality picture.
27. Dropout/noise compensator.
28. Automatic rewind at the end of the tape. The tape stops and fully rewinds automatically.

*TBC . . .Time Base Corrector.

■ VOLTAGE ADJUSTMENT

To adjust the voltage selector, turn the voltage selector with a screwdriver.

CAUTION: **Operation at a voltage setting higher than 125VAC may require the use of a different AC plug or cord set. Please contact either a local or foreign Panasonic authorized service center for assistance in selecting an alternate AC plug or cord set.**



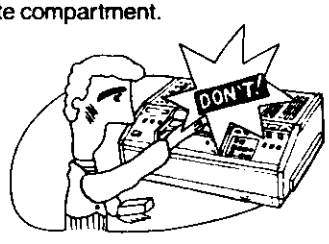
SETTING THE VOLTAGE SELECTOR				
LOCAL VOLTAGE	AC 100 V	AC 120 V	AC 220 V	AC 240 V

CAUTION: Voltage Settings 100 V, 220 V and 240 V are not intended for use in USA.

PRECAUTIONS

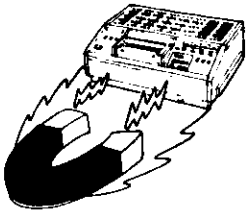
WARNING—THIS EQUIPMENT GENERATES, USES, AND CAN RADIATE RADIO FREQUENCY ENERGY AND IF NOT INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTIONS MANUAL, MAY CAUSE INTERFERENCE TO RADIO COMMUNICATIONS. IT HAS BEEN TESTED AND FOUND TO COMPLY WITH THE LIMITS FOR A CLASS A COMPUTING DEVICE PURSUANT TO SUBPART J OF PART 15 OF FCC RULES, WHICH ARE DESIGNED TO PROVIDE REASONABLE PROTECTION AGAINST SUCH INTERFERENCE WHEN OPERATED IN A COMMERCIAL ENVIRONMENT.
OPERATION OF THIS EQUIPMENT IN A RESIDENTIAL AREA IS LIKELY TO CAUSE INTERFERENCE IN WHICH CAUSE THE USER AT HIS OWN EXPENSE WILL REQUIRED TO TAKE WHATEVER MEASURES MAY BE REQUIRED TO CORRECT THE INTERFERENCE.

Do not insert fingers or any other object into the video cassette compartment.

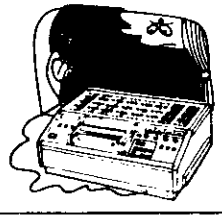


If this unit is suddenly moved from a cold to a warm place, condensation may form inside. Therefore wait for at least 60 minutes before operating again while turning on the machine.

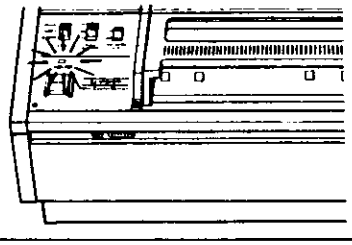
Avoid operating or leaving the unit near strong magnetic fields. Be especially careful of large audio speakers.



Avoid operating or storing the unit in an excessively hot, cold, or damp environment as this may result in damage both to the recorder and to the tape.



If, as described above, excessive moisture or condensation does form inside the recorder, the Auto OFF light will glow if the power is ON.
While the Auto OFF light is on, the unit will not function. Let the unit remain at a room temperature with power ON until the Auto OFF light is no longer illuminated.



- Do not block the ventilation slots on the top and bottom of the unit.
- Use this unit horizontally and do not place anything on the top panel.
- Cassette tape can be used only for one-side, one direction recording. Two-way or two-track recordings cannot be made.
- Cassette tape can be used for either Color or Black & White recording.
- This unit is supplied with a 3-prong grounded AC plug—do not try to defeat its purpose.
- Do not spray any cleaner or wax directly on the unit.
- If the unit is not going to be used for a length of time, protect it from dirt and dust by using the dust cover.
- Do not leave a cassette in the recorder when not in use.
- Do not attempt to disassemble the recorder. There are no user serviceable parts inside.
- If any liquid spills inside the recorder, have the recorder examined for possible damage.
- Refer any needed servicing to qualified service personnel.

"Unauthorized recording of copyrighted television programs, films, video tapes and other materials may infringe the right of copyright owners and be contrary to copyright laws."

Note:

- Please read the attached warranty card completely.

FOR YOUR SAFETY

WARNING: TO PREVENT FIRE OR SHOCK HAZARD, DO NOT EXPOSE THIS EQUIPMENT TO RAIN OR MOISTURE.

INSPECTION OF YOUR Panasonic NV-9240

After removing the recorder from its box, check it to be sure it has not sustained any damage. Also check to see that you have the following accessories as they are illustrated below.

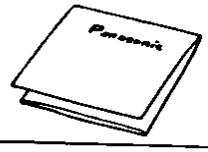
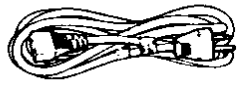
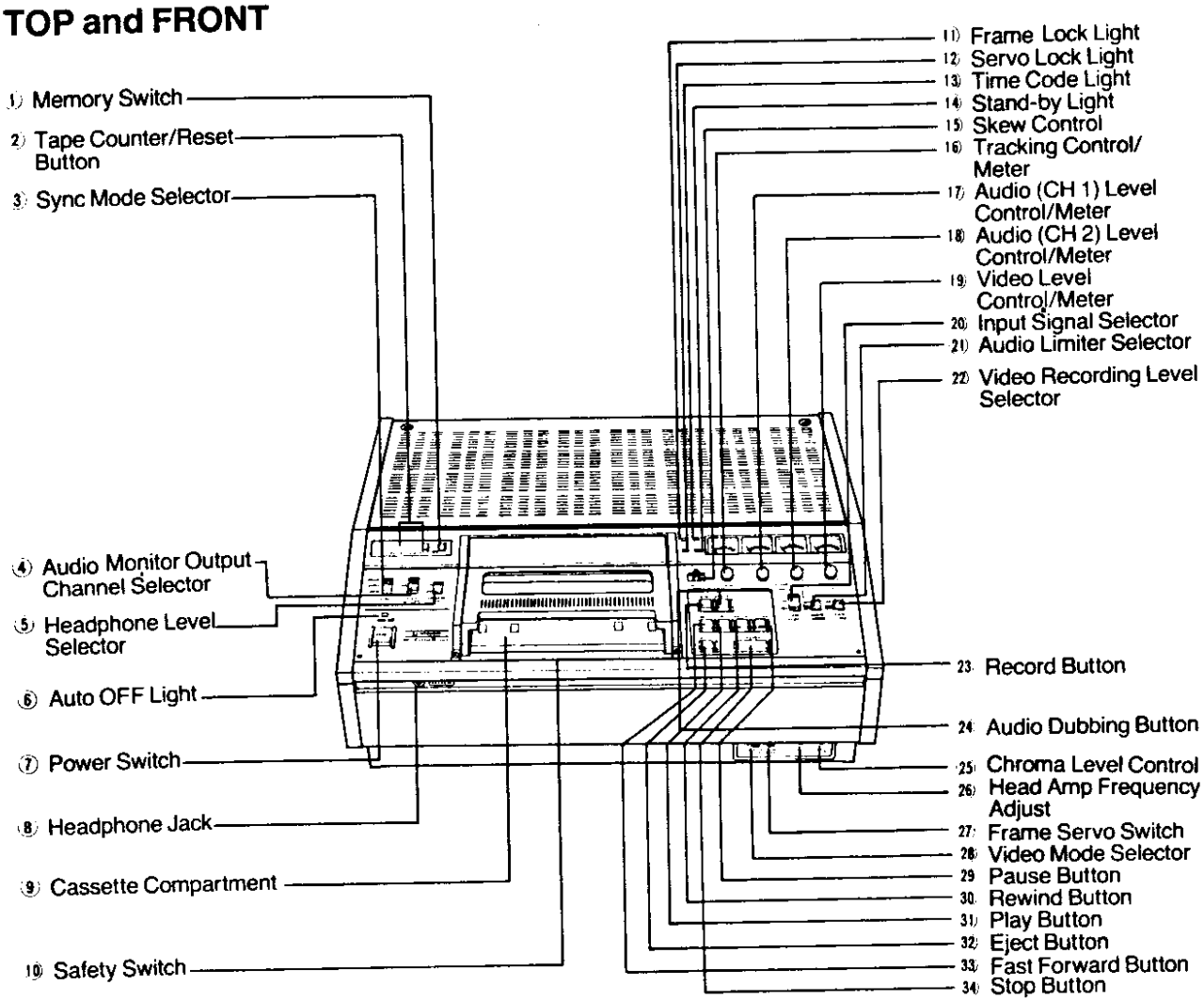
Accessories	Part Number
1 pc. Dust Cover 	VFB0006
1 pc. AC Power Cord 	VJA0129

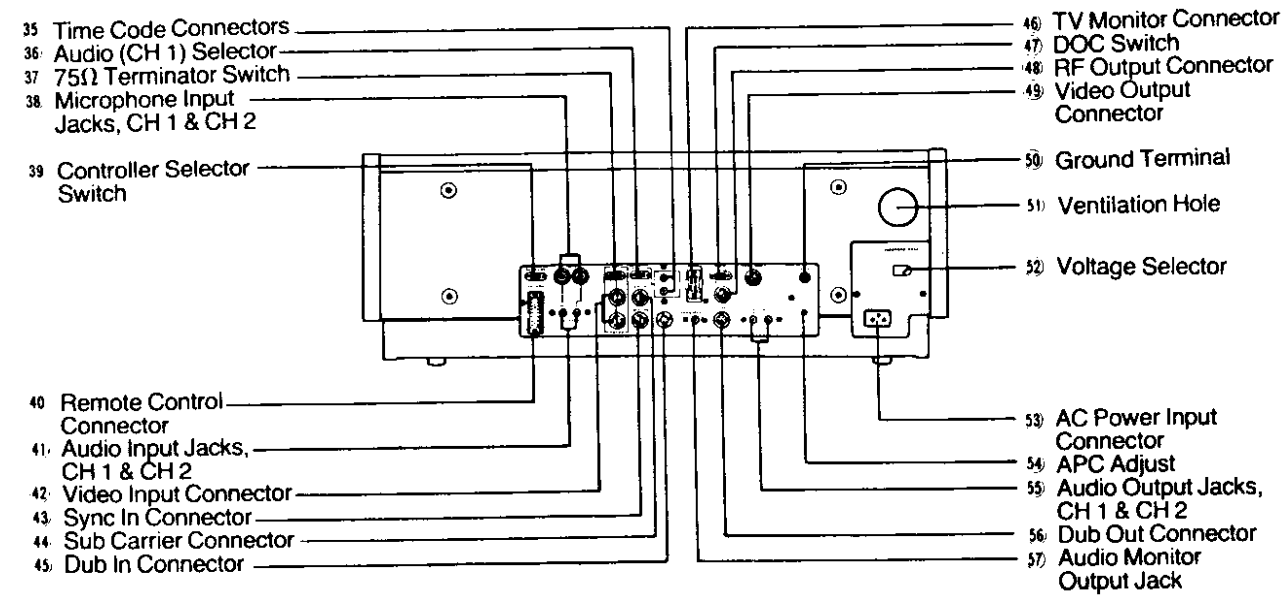
TABLE OF CONTENTS

MAJOR OPERATING COMPONENTS

TOP and FRONT



REAR



CONTROLS AND THEIR FUNCTIONS

TOP and FRONT

① **Memory Switch [MEMORY]**
When this switch is in the "ON" position, the tape will automatically stop during rewind or fast forward when the Tape Counter display indicates nearly "0000".
By starting the recording from this "0000" point, subsequent playback location will be more convenient.

② **Tape Counter/Reset Button [COUNTER]**
When the Reset Button is pressed, the Tape Counter display will reset to "0000".
When tape is rewound beyond the "0000" position, the display will show "−".

③ **Sync Mode Selector [SYNC]**
This selector determines the input to synchronize the servo, from three types of signals: external, internal or normal (incoming video). (See page 11 for details.)

④ **Audio Monitor Output Channel Selector [AUDIO MONITOR]**
Selects the audio channel desired to be heard on the TV monitor, headphone, or through Audio Monitor Output Jack.
CH1: To monitor audio CH1 only.
MIX: To monitor mixed audio of both CH1 and CH2.
CH2: To monitor audio CH2 only.

⑤ **Headphone Level Selector [HEADPHONE LEVEL]**
This switch sets the headphone volume (high and low).

⑥ **Auto OFF Light [AUTO OFF]**
When illuminated, this light indicates that excessive moisture is present inside the deck. When something wrong happens inside the deck this light will flash.

⑦ **Power Switch [POWER]**
Press this switch to turn the unit ON. This switch will light. The Tape Counter display will show "0000", and the meters for audio CH1/CH2, video and tracking will light.
Press again to turn the unit off.

⑧ **Headphone Jack [HEADPHONES]**
Permits listening with headphones to the channel or channels selected by the Audio Monitor Output Channel Selector.

⑨ **Cassette Compartment**
For insertion of a cassette tape.

⑩ **Safety Switch**
This is the switch for safety guard for protecting your finger from being pinched between a cassette and switch. When you touch this switch while the cassette compartment is going down, the cassette compartment will raise again.

⑪ **Frame Lock Light [FRAME LOCK]**
This light illuminates when the Frame Servo Switch is set to "ON".
Before recording or playback, be sure to set the Frame Servo Switch to ON unless a non standard signal is involved.

⑫ **Servo Lock Light [SERVO LOCK]**
This light is on when the servo circuit is synchronized with a standard signal.

⑬ **Time Code Light [TIME CODE]**
This light is on when the time code signal is used. When this light is extinguished or goes on and off, it indicates that the time code signal is not recorded on the tape.

⑭ **Stand-by Light [STAND BY]**
The Stand-by Light is "ON" while the cassette tape is loading or unloading.

⑮ **Skew Control [SKEW]**
Move this control to "L" when an slight bend occurs on the right upper part of the playback picture.
Move this control to "R" when an slight bend occurs on the left upper part of the playback picture.

⑯ **Tracking Control/Meter [TRACKING]**
Normally leaves this in its center "FIX" detent position. Occasionally tapes made on other video cassette recorders may exhibit noise or streaks in the playback picture. Adjust the Tracking Control so that the Tracking Meter reads maximum (green).

⑰ **Audio (CH1) Level Control/Meter [AUDIO LEVEL CH1]**
Controls the audio CH1 recording level. Should be adjusted so that the Level Meter needle rarely deflects beyond the 0 dB position.
When the Audio (CH1) Selector on the rear panel is set to TIME CODE, the meter light will be extinguished because the audio CH1 cannot be used.

⑱ **Audio (CH2) Level Control/Meter [AUDIO LEVEL CH2]**
Controls the audio CH2 recording level. Should be adjusted so that the Level Meter needle rarely deflects beyond the 0 dB position.

⑲ **Video Recording Level Control/Meter [VIDEO LEVEL]**
When Video Recording Level Selector is set at MAN., turn this control to adjust the video recording level while visually referring to the Level Meter.
Adjust the recording level to the blue region of the meter.

⑳ **Input Signal Selector [INPUT SELECT]**
TV: To record from the TV monitor connected to the TV Monitor Connector.
LINE: To record from a video camera or video signal connected to the Video Input Connector.
DUB: To do dubbing with the dubbing cable (7-pin), or video cable (BNC).

㉑ **Audio Limiter Selector [AUDIO LIMITER]**
ON: During recording, minimizes distortion from peak levels.
OFF: Peak levels are not limited.

㉒ **Video Recording Level Selector [VIDEO LEVEL]**
MAN: Adjust the video recording level with Video Recording Level Control.
AGC: Video recording level is adjusted automatically.

㉓ **Record Button [REC]**
This button should be pressed simultaneously with the Play Button to start recording both picture and sound.

㉔ **Audio Dubbing Button [AUDIO DUB]**
Press this button while pressing the Play Button during playback to place new audio on the tape.
(Channel 1 only used for Audio Dub.)
For details, see page 23.

㉕ **Chroma Level Control [CHROMA LEVEL]**
Used to adjust the chrominance level if the proportion of chroma to luminance is not normal. This should be adjusted with a waveform monitor or oscilloscope. Set this at center detent position under normal conditions.

㉖ **Head Amp Frequency Adjust [HEAD AMP FREQ ADJ]**
Turn to the left to soften the picture and turn to the right to sharpen the picture.
Set this at center detent position under normal conditions.

㉗ **Frame Servo Switch [FRAME SERVO]**
ON: Turn the switch ON to record or play back 2:1 interlaced standard (EIA RS-170A) signal.
Frame Lock Light is ON in this position.
OFF: Turn the switch OFF to record or play back non-interlaced signals.
Frame Lock Light is OFF in this position.

㉘ **Video Mode Selector [VIDEO MODE]**
Selects B/W or Color signal.
AUTO: Distinguishes automatically between Black & White and Color video input signals or playback video signals.
Normally, set this selector in this position.
B/W: Makes video input signal or playback video signal black and white.

㉙ **Pause Button [PAUSE]**
Press this button to stop the tape movement in either the record or playback mode, and the pause lamp lights. A still picture will appear in the playback mode if the proper tape is used. See page 8 for details. Press again to release pause.

㉚ **Rewind Button [REW]**
When this button is pressed, the cassette tape is rewound rapidly to the supply reel.

㉛ **Play Button [PLAY]**
Pressing this button causes the tape to start playback. If Record Button is held down first, and then this button is pressed, the unit will go into the recording mode.

㉜ **Eject Button [EJECT]**
To insert or remove a cassette tape, press this button, and the Cassette Compartment will be elevated.
If this button is pressed while the tape is moving, (such as during playback, fast forward or rewind), and the unit will stop and then eject.

㉝ **Fast Forward Button [FF]**
When this button is pressed, the tape is forwarded rapidly to the takeup reel.

㉞ **Stop Button [STOP]**
Used to stop the tape movement.

REAR

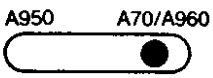
㉟ **Time Code Connectors [TIME CODE]**
Use this connector to record or read out the time code signal.
IN: Connection point for Time Code recording.
OUT: Connection point for Time Code playback.

㊱ **Audio (CH1) Selector [AUDIO CH1 SELECT]**
This is the selection switch for audio CH1 or time code signal.
TIME CODE: To use time code signal.
AUDIO: To use audio CH1 signal.

㊲ **75Ω Terminator Switch [75Ω]**
This is termination switch for video signal.
ON: To terminate video signal.
OFF: Bridging.

㊳ **Microphone Input Jacks, CH1 & CH2 [MIC]**
For connection of microphones.

㊴ **Controller Selector Switch [CONTROLLER SELECT]**
Use this switch to select the type of Editing Controller.



A950: Set the switch to this position to use Editing Controller NV-A950.
A70/A960: Set the switch to this position to use Editing Controller NV-A960 or Auto Editing Controller AU-A70.

㊵ **Remote Control Connector [REMOTE]**
For connection to an Editing Controller (NV-A950/NV-A960) or Auto Editing Controller (AU-A70), or Remote Control Unit NV-A152.

㊶ **Audio Input Jacks, CH1 & CH2 [AUDIO IN]**
Line level audio signal input for recording.

㊷ **Video Input Connector [VIDEO IN]**
For connection of the video camera or video signal.

㊸ **Sync In Connector [SYNC IN]**
To synchronize to an external sync source, connect external standard composite sync signal to this connector.

㊹ **Sub Carrier Connector [SC IN]**
When a time base corrector is used with this unit, connect the subcarrier output of the time base corrector to this connector.

㊺ **Dub In Connector [DUB IN]**
Receives signal from the Dub Out Connector of the play VCR via the 7-pin dubbing cable (accessory included).

㊻ **TV Monitor Connector [TV]**
For connection of a TV monitor (having an 8-pin connector) by using the VTR-monitor connection cable. For audio, only CH2 is used at the 8-pin connector.

㊼ **DOC Switch [DOC]**
The Dropout Compensator On and Off switch. Place this switch in "OFF" position when the Time Base Corrector has an internal DOC and is connected to the RF Output Connector.
This eliminates double dropout compensation in both VCR and TBC.

㊽ **RF Output Connector [RF OUT]**
To be connected to a Time Base Corrector which is equipped with Dropout Compensator.
Output signal: RF signal, 0.5Vp-p at 75 ohm terminated.

㊾ **Video Output Connector [VIDEO OUT]**
Video signal line out.

㊿ **Ground Terminal [GND]**
Connect to external ground, if audio hum or buzz is heard while monitoring or playing back.

(51) **Ventilation Hole**

(52) **Voltage Selector [VOLTAGE SELECT]**
This selector can be set for 100, 120, 220, 240 Volt operation.
If it is necessary to change the voltage (preset to 120V at the factory), consult page 1.

(53) **AC Power Input Connector [AC IN]**
Connect the power cord between this connector and an AC power outlet.

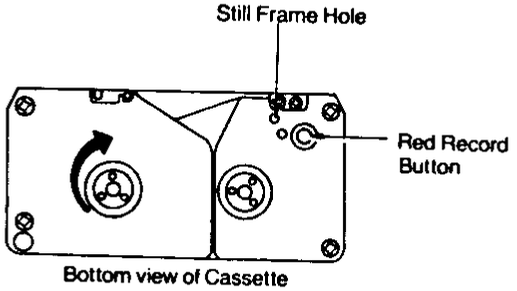
(54) **APC Adjust [APC]**
This control is preset at factory, and under normal operating conditions it will not require any adjustment. If the playback picture shifts in hue or completely loses all color, try turning the recessed control slowly to the right or left with a flat blade screwdriver until a normal color picture reappears.

(55) **Audio Output Jacks, CH1 & CH2 [AUDIO OUT]**
Audio signal line out.

(56) **Dub Out Connector [DUB OUT]**
Sends signal to the Dub In Connector of the recording VCR via the 7-pin dubbing cable (accessory included).

(57) **Audio Monitor Output Jack [AUDIO MONITOR]**
For connection to audio amplifier, or audio input of TV monitor, this allows monitoring of channel 1 or channel 2 or mixed audio, as selected by the Audio Monitor Output Channel Selector.

VIDEO CASSETTE IDENTIFICATION



Bottom view of Cassette

The bottom of a video cassette has several holes to identify functional capability.

Large hole with removable red button

This hole determines whether a video cassette can be used for recording and playback, or for playback only, depending upon whether the red button is place.

■ **Red button inserted into large hole.**

If the red button is inserted into the large hole, then the video cassette can be used for recording playback and audio dubbing.

■ **Red button removed from large hole.**

If the red button has been removed from the large hole, then the video cassette can be used for playback only. This is a special feature which prevents accidental erasure of a pre-recorded program.

Still-frame playback hole

Panasonic's present cassettes use 3/4" video tape capable of withstanding the tape wear encountered during still frame operation. Some 3/4" video cassette tape was not designed for this type of operation. When such tape is played back and the Pause Button is pressed, rather than allowing the video heads to be clogged, tape tension is released, and no still image appears. The recorder automatically determines whether a particular video cassette is capable of still frame playback.

How to identify video cassette

■ **Video cassette designed for still frame playback.**

A video cassette designed for still frame playback has two small holes near the large record hole. Such a cassette tape will produce a still image when the Pause Button is pressed during playback.

Caution:

If the PAUSE mode is left for more than 10 minutes, the unit will automatically go into the stop mode, to protect the tape.

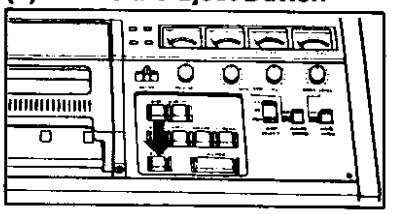
■ **Video cassette not designed for still frame playback.**

A video cassette not designed for still frame playback has one small hole near the large record hole. Such a cassette tape will not produce a still image when the Pause Button is pressed during playback. Tape motion will stop and normal playback will resume when the Pause Button pressed again.

FUNDAMENTAL OPERATIONS

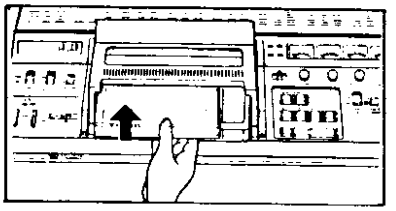
■ How to remove the cassette tape

(1) Press the Eject Button



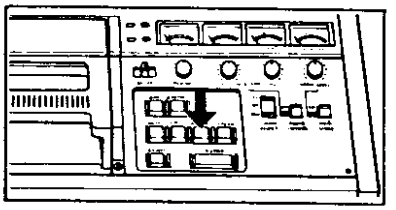
Press the Eject Button and the Cassette Compartment will be gently elevated.

(2) Insertion of the cassette tape



Insert the cassette tape fully into the Cassette Compartment.

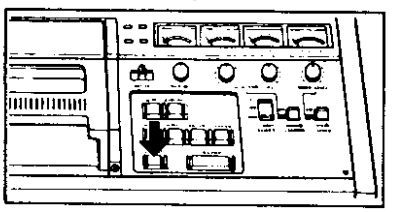
(3) Lower the cassette operation



Press the Rewind Button. Then the cassette tape will lower and the tape will be rewound to the reel on the right (the supply reel). It will automatically stop at the beginning of the tape.

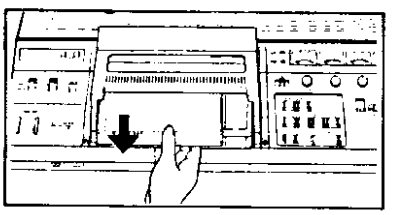
■ How to insert the cassette tape

(1) Press the Eject Button



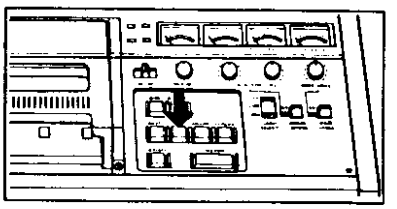
To exchange or remove a video cassette tape, press the Eject Button while operating in any mode and the Cassette Compartment will be gently elevated for easy removal of the cassette tape.

(2) Remove a video cassette tape



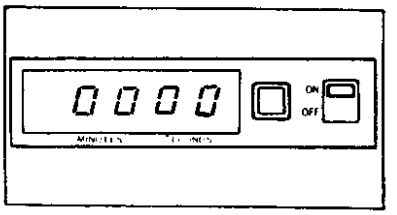
After the Cassette Compartment is elevated completely, remove the video cassette tape.

(3) Lower the Cassette Compartment



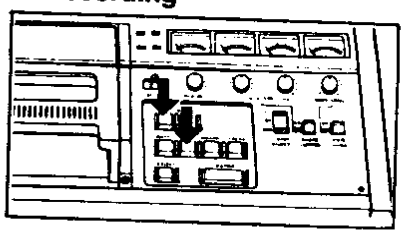
If either the Play, Rewind or Fast Forward button is pressed the Cassette Compartment will lower, even if no cassette is installed.

■ Tape Counter



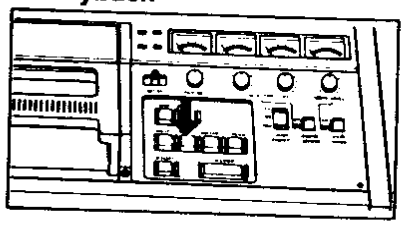
This tape counter will count and display CTL pulse in accordance with tape movement. When the Reset Button is pressed, the counter display will be "0000".
When the Memory Switch is set to "ON", the tape will automatically stop during rewind or fast forward when the Tape Counter display indicates nearly "0000".
By starting the recording from this "0000" point, subsequent playback will be more convenient.

■ Recording



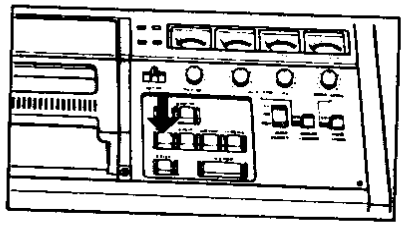
Press the Play Button while pressing the Record Button.
Video and audio recording is made immediately after the Stand-by Light goes off.
When the tape reaches its end, it will automatically be rewound by the automatic-rewind system.

■ Playback



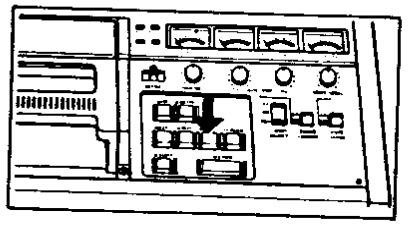
To play back the tape, press the Play Button and the Stand-by Light will glow while the cassette tape is loading. After a few seconds the light will go out, and playback will begin. The picture will then appear on the TV monitor.

■ Fast forward



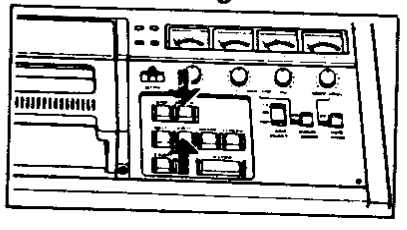
The Fast Forward Button can be used to rapidly advance the tape to the position desired for playback or recording.

■ Rewinding



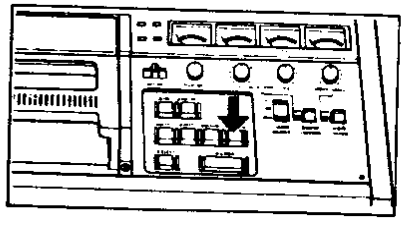
When the Rewind Button is pressed, the tape is rewound to the reel on the right (the supply reel).

■ Audio Dubbing



Press this button while pressing the Play Button during playback if it is desired to place a new audio track on Audio CH1. This will not affect the video or audio CH2 portion of the tape. The microphone or audio (line) input must be connected for dub source. See Audio Dub Section, page 23.

■ Pause

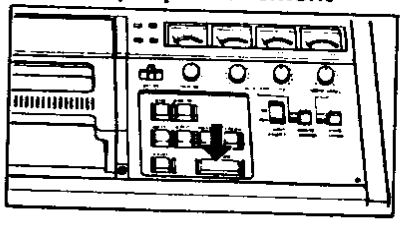


During recording or playback, to momentarily stop the tape, press the Pause Button.
During record, while the tape has stopped, recording cannot be performed. During playback, while the tape has stopped, either a still image will appear, or the picture will be muted. This depends upon the type of tape used. See page 8 for details. To resume recording or normal playback, press the Pause Button again.
Recording or playback will immediately resume.

Note:

If the Pause mode is left for more than 10 minutes, the unit will automatically go into the stop mode, to protect the tape.

■ To stop tape movement



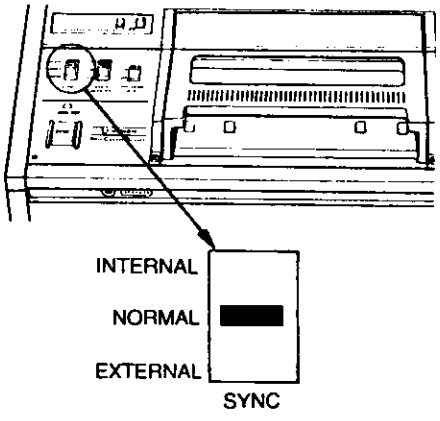
To stop all other functions, press Stop Button.

ADJUSTMENT BEFORE RECORDING OR PLAYBACK

Be sure to set the recorder to STOP mode (E-E picture) before trying to adjust the following switches.

■ SYNC MODE SELECTOR

The Sync Mode Selector is used to determine the source to which the VCR is synchronized during Record or Playback.

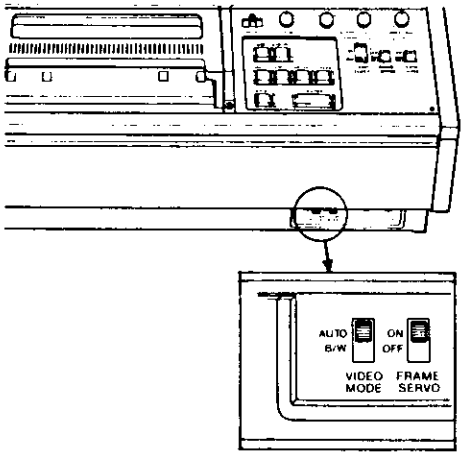


1. **INTERNAL:** The tape is synchronized with internal 60 Hz oscillator (derived from internal crystal source). This mode is primarily used for playback.
2. **NORMAL:** The tape is synchronized with the input video signal. This mode is used for recording or playback.

   Notes: (1) If during playback, the input video signal is noisy or unstable, switch to the "INTERNAL" position.

   (2) If during playback, there is no input video signal, synchronization automatically switches to internal.
3. **EXTERNAL:** The tape is synchronized with the external composite sync which is connected to the Sync In Connector on the rear panel. For better stability, synchronize with an external composite sync signal.
   However, whatever signal is being recorded, must be in phase with the external composite sync signal.
   Otherwise the recording will be useless.

■ VIDEO MODE SELECTOR



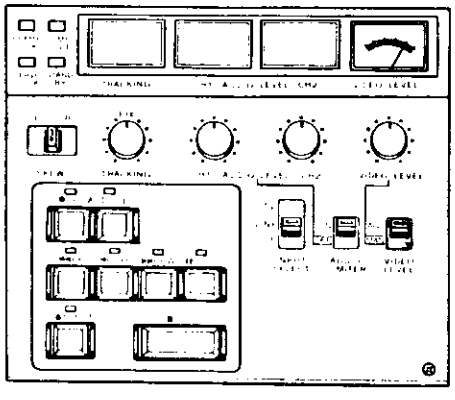
Set this selector normally at "AUTO" position.

AUTO: To record either Color or Black & White video input signal by distinguishing automatically between them.

B/W: To record all video input signal in the black and white mode.
When playing back a color program on a B/W monitor, color dot interference can be eliminated by setting this switch to B/W.

Note that color programs will play back in the black and white mode if the Video Mode Selector is set to "B/W".

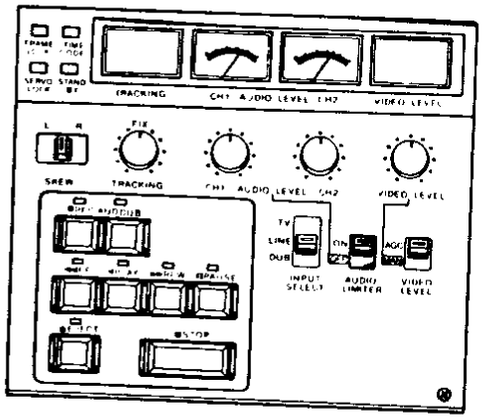
■ VIDEO LEVEL ADJUSTMENT



AGC: **Automatic Gain Control**
Set the Video Recording Level Selector to "AGC" position, and the video recording level is adjusted automatically.
In the AGC mode the Video Recording Level Control does not operate. This is the mode normally used for recording.

MAN: **Manual Gain Control**
Set the Video Recording Level Selector to "MAN" position, and adjust the video recording level with the Video Recording Level Control so the meter points to the blue portion.

■ AUDIO (CH 1/CH 2) LEVEL ADJUSTMENT



Gain Control (ch 1)

Adjust Audio (ch 1) Recording Level Control so the meter rarely deflects beyond 0 dB on peaks.

NOTE:

When you record time code signal the audio CH1 cannot be used because the time code signal is recorded onto the audio CH1 track of the tape.

Gain Control (ch 2)

Adjust so the meter rarely deflects beyond 0 dB on peaks.

NOTE:

When recording from a TV monitor, the audio is recorded on channel 2 only.

AUDIO LIMITER SELECTOR

ON: To minimize distortion from peak levels set Audio Limiter Selector to "ON" position. This permits the average level to be set higher for better signal to noise ratio.

OFF: This permits maximum dynamic range to be recorded, but the level must be set low enough so that peaks do not cause objectionable distortion.

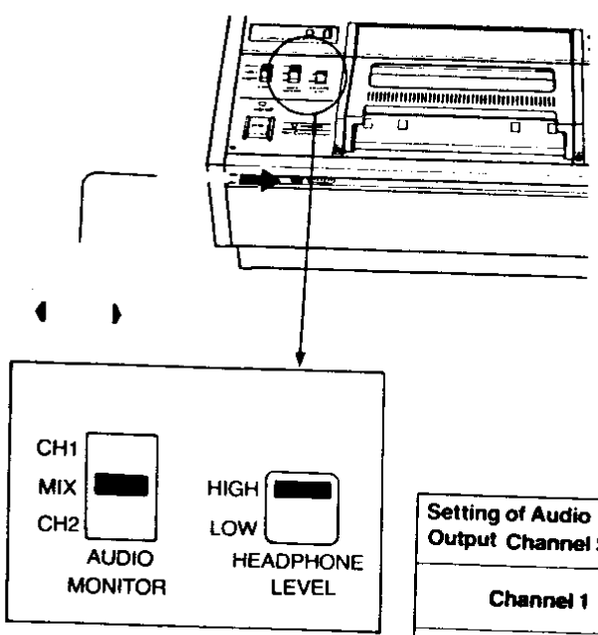
Note:

The Audio Limiter Selector controls both channels simultaneously.

•Playback

Audio level cannot be adjusted during playback with this unit even though the level meter needle indicates the recorded audio level.

■ AUDIO MONITOR OUTPUT CHANNEL SELECTOR and HEADPHONE LEVEL SELECTOR



•AUDIO MONITOR OUTPUT CHANNEL SELECTOR

The Audio Monitor Output Channel Selector is used to select the audio output signal. Its selected signal is heard on the TV monitor or headphones.

Notes:

- If the Audio (CH1) Selector is set to "AUDIO" and the TIME CODE signal has already been recorded on the audio CH1 track of the tape, please turn the Audio Monitor Output Channel Selector to "CH2". (If you set its selector to "MIX" or "CH1" position, you will hear a shrill, abnormal sound.)
- If the Audio (CH1) Selector is set to "TIME CODE" position, no audio sound can be heard, even if the Audio Monitor Output Channel Selector is set to "CH1".

•HEADPHONE LEVEL SELECTOR

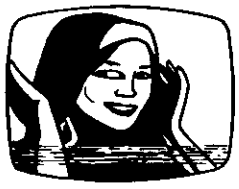
When using the headphones, you can either "HIGH" or "LOW" volume by using the Headphone Level Selector.

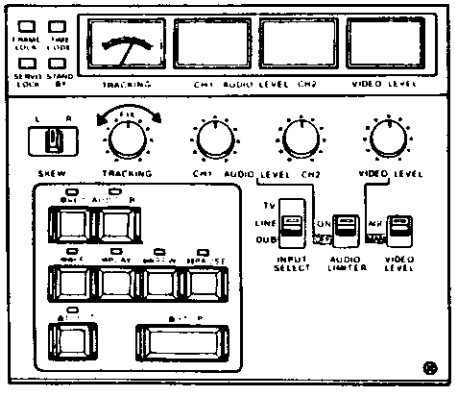
Setting of Audio Monitor Output Channel Selector	TV Monitor Connector Audio Monitor Output Jack	Headphone Jack
Channel 1	Audio from channel 1 only	Audio from channel 1 only
MIX	Sound from both channels will be mixed	(Not mixed) Each headphone hears separate channel Channel 1 . . . Left Channel 2 . . .Right
Channel 2	Audio from channel 2 only	Audio from channel 2 only

Note:

When using the Audio Output Jacks CH1/CH2, both audio signals are not affected by the Audio Monitor Output Channel Selector setting.

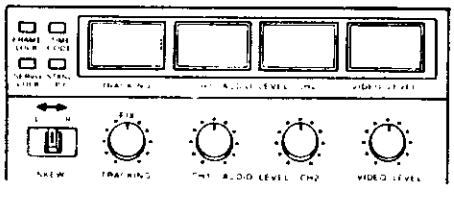
■ TRACKING CONTROL





Normally tapes should be played back with the Tracking Control at the "FIX" position.
When playing some non-standard tapes or those recorded on another machine, streaks or noises may appear on the TV monitor. If this occurs, adjust this control. Turn the Tracking Control slowly in either direction until the picture is clear, and the tracking meter indicates maximum.
When the appropriate location is determined, leave the control at that position when playing back that tape. When playback of this particular tape is finished, reset the Tracking Control to "FIX".

■ SKEW CONTROL

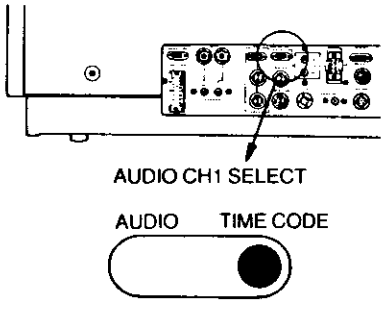


This control is used to correct a slight right or left bend in the upper part of the playback picture.
Stop moving it when the image appears to be corrected.

- Move this control to "L" side when an slight bend occurs on the right upper part of the playback picture.

- Move this control to "R" side when an slight bend occurs on the left upper part of the playback picture.

■ AUDIO (CH 1) SELECTOR (REAR PANEL)



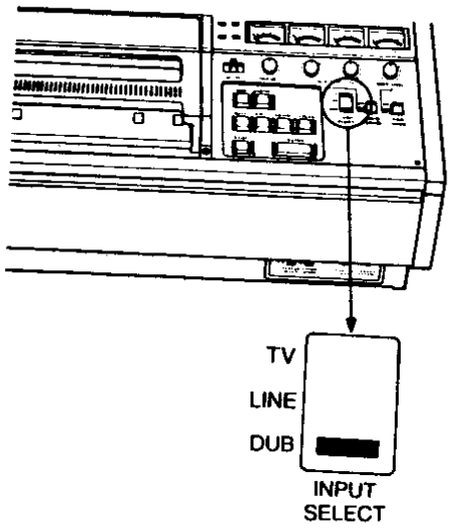
This control is used to select either Audio CH1or TIME CODE signal.

AUDIO: To record or play back audio signal on CH1.
(Audio (CH1) Level Meter on front panel is on.)

TIME CODE: To record or play back time code signal.
(Audio (CH1) Level Meter on front panel is off.)

■ INPUT SIGNAL SELECTOR

The Input Signal Selector is used to select the source of audio, video inputs, and also to obtain better color quality for dubbing. By setting this selector, the Automatic Phase Control (APC) circuit is enabled or disabled under various conditions.



TV: To record audio, video signals from a TV monitor through TV Monitor Connector (8-pin), set the Input Signal Selector to "TV" position.

LINE: To record audio and video signals from a camera through Video Input Connector (BNC) and Audio Input Jack (RCA), set the Input Signal Selector to "LINE" position.
During recording or playback, the APC and noise eliminator are ON, which corrects the instability of the chrominance portion, giving a good color image for the TV Monitor.

DUB: To do dubbing by using the dubbing cable (7-pin), or video cable (BNC), set the Input Signal Selector to "DUB" position.
Under this condition, the APC and noise eliminator are OFF, making the chrominance portion unstable but perfectly interleaved with the luminance portion. This creates less color noise, with the result being a good quality picture (especially on multigeneration tapes) when this signal is recorded by the dubbing machine.

Position of Input Signal Selector	Use of the input source		
	Use of TV	Use of camera	Dubbing
TV	Recommended	Not recommended	Not recommended
LINE	Not recommended	Recommended	Recommended
DUB	Not recommended	Not recommended	Recommended *

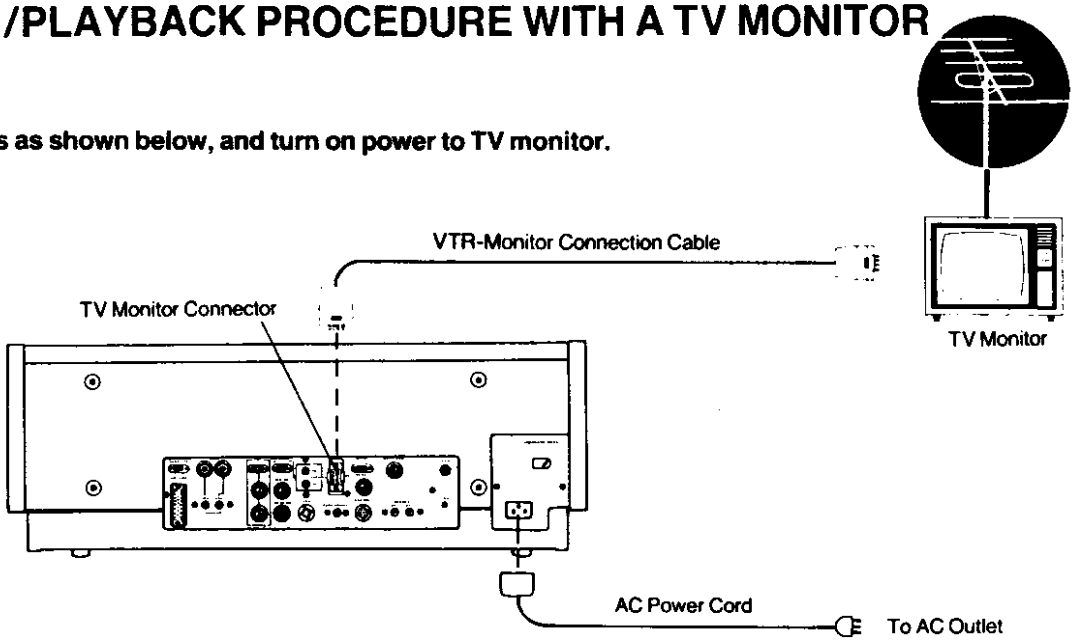
Notes:

- When you want to do dubbing, it is recommended to set the Input Signal Selector at "DUB" position.
- * The color of the TV monitor connected to the playback VCR may not come out stable when the BNC type cable is used for video signal. But this is not a malfunction.

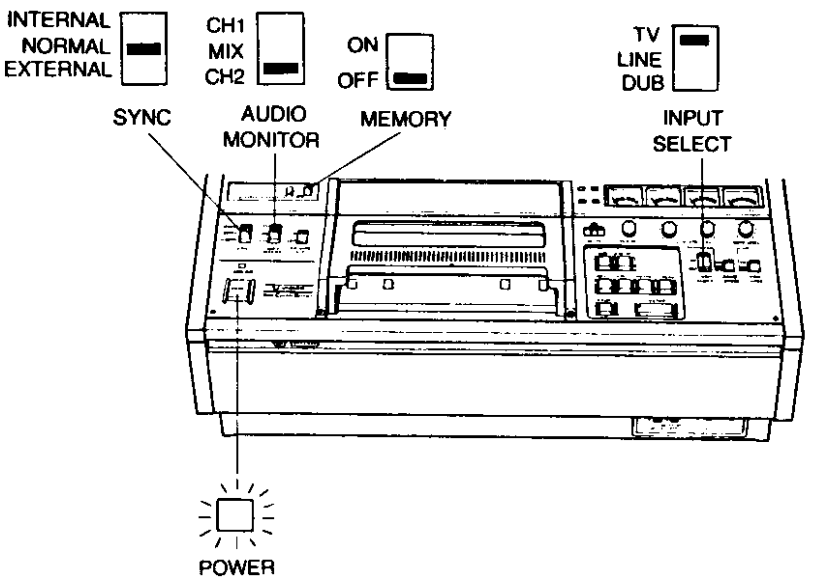
RECORDING/PLAYBACK PROCEDURE WITH A TV MONITOR

PROCEDURE

1. **Make connections as shown below, and turn on power to TV monitor.**



2. **Set each switch as shown below and press the Power Switch to turn on.**

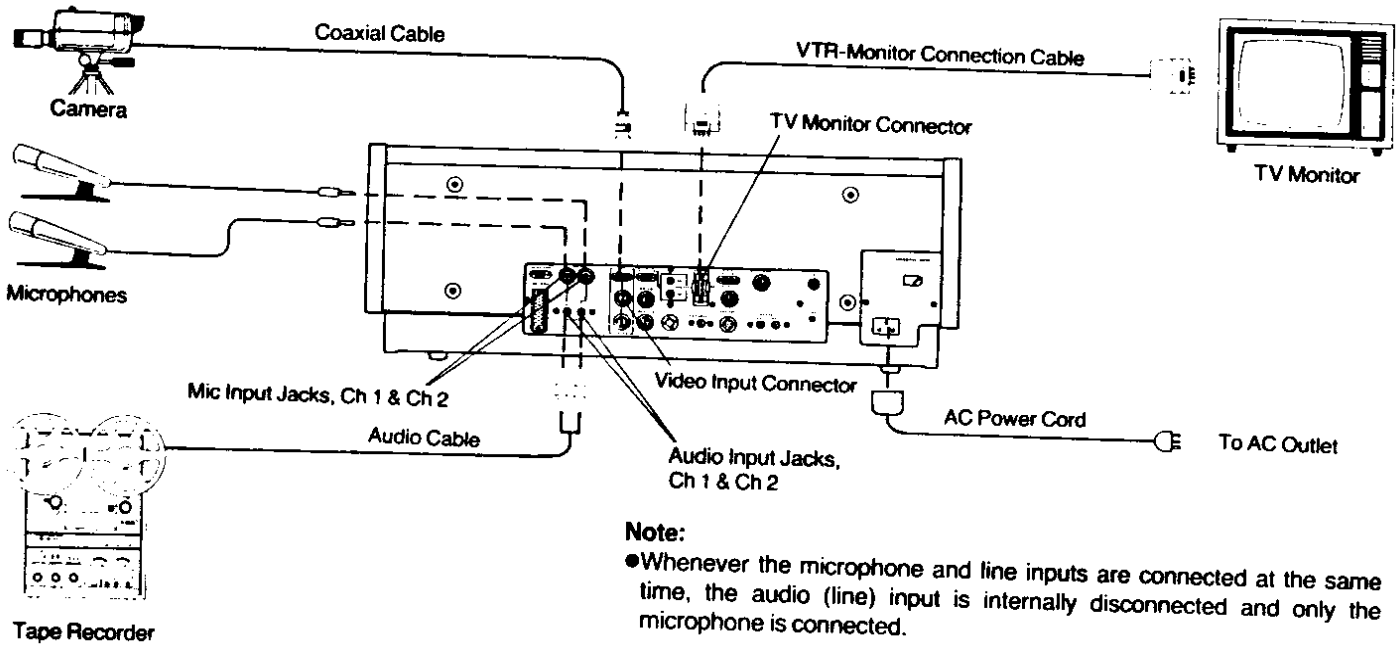


3. **Insert the cassette tape.**
4. **Select the desired TV program.**
5. **Adjust the Video level, or set Video Recording Level Selector to "AGC".**
6. **Adjust the Audio (CH2) level, or set Audio Limiter Selector to "ON".**
7. **Perform RECORDING, PLAYBACK, PAUSE, REW, FF and STOP as desired according to the Fundamental Operation, Page 10.**

RECORDING/PLAYBACK PROCEDURE WITH A VIDEO CAMERA

PROCEDURE

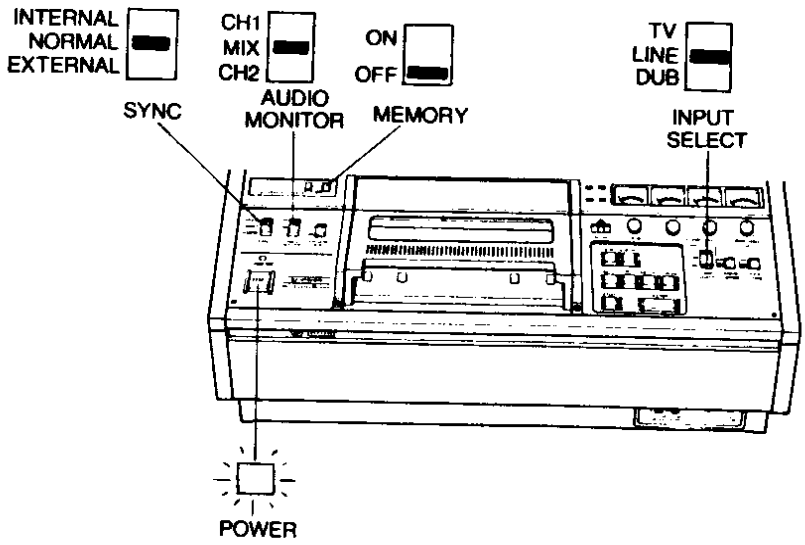
1. **Make connections as shown below, and turn on power to TV monitor.**



Note:

- Whenever the microphone and line inputs are connected at the same time, the audio (line) input is internally disconnected and only the microphone is connected.

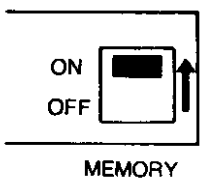
2. **Set each switch as shown below and press the Power Switch to turn on.**

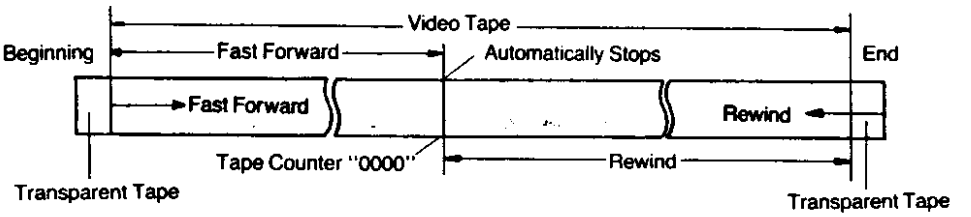


3. **Insert the cassette tape.**
4. **Connection of the desired camera and Audio set-up at the studio.**
5. **Adjust the Video level, or set Video Recording Level Selector to "AGC".**
6. **Adjust the Audio (CH1/CH2) level, or set Audio Limiter Selector to "ON".**
7. **Perform RECORDING, PLAYBACK, PAUSE, REW, FF and STOP as desired according to the Fundamental Operation, page 10.**

AUTOMATIC SEARCH

When the Memory Switch is set to the "ON" position, the tape will automatically stop during rewind or fast forward when the tape counter display indicates nearly "0000".

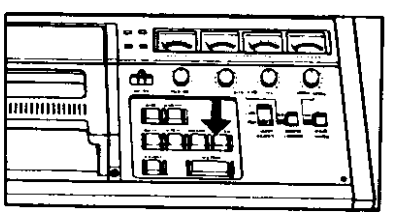




1. **Locate the desired position of the tape.**
2. **Set the tape counter to "0000" by pressing the Tape Counter/Reset Button at desired point for recording/ playback.**
3. **Set the Memory Switch to "ON".**
4. **Now whenever in the fast forward or rewind modes, the tape will automatically stop at the desired spot.**

PAUSE OPERATION

Press the Pause Button for still pictures during playback, or for momentary pause during recording.



■ Still mode

During playback, when the Pause Button is pressed and the proper tape is used, a still image will appear. See page 8 for details. To resume playback, press the Pause Button again.

■ Simple electronic gathering (editing)

1. To record a program B after the pre-recorded program A, first, playback the program A.
2. Press the Pause Button at the point where it is desired to join program A and B. A still image of program A will appear, if the proper tape is used.
3. Press the Record Button and adjust Video Level or select AGC.
4. To begin recording, press the Pause Button again, and program B will start being recorded.

■ Stop during recording

1. During recording, to stop the tape, press Pause Button.
2. To resume recording, press the Pause Button again.

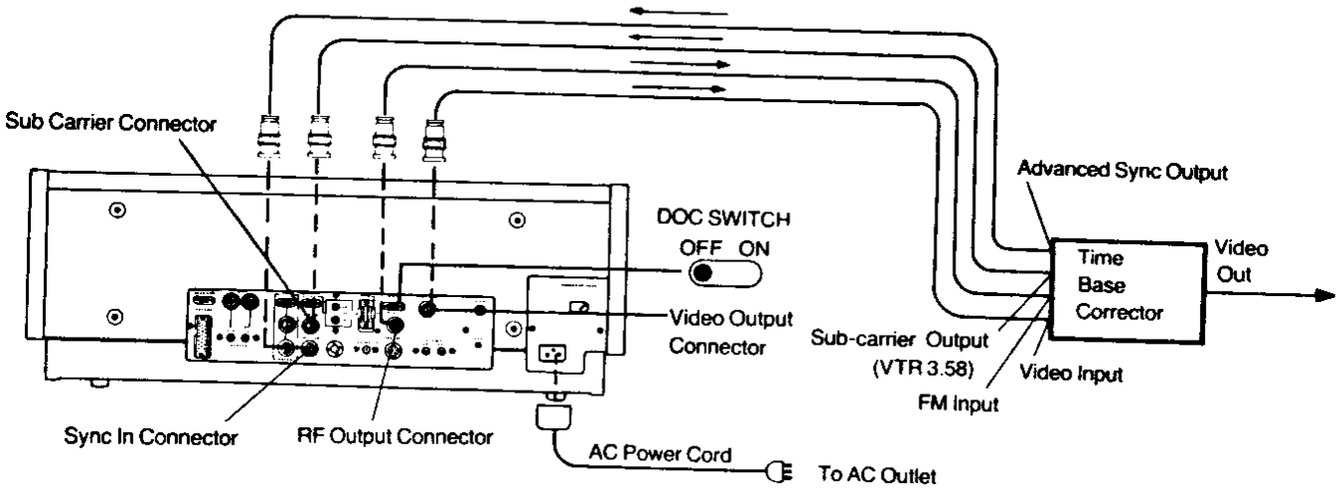
CAUTION:
If the Pause mode is left for more than 10 minutes, the unit will automatically go into the stop mode.

USING THE NV-9240 IN CONJUNCTION WITH A TIME BASE CORRECTOR

The NV-9240, with its Direct Drive Head Cylinder and Capstan Servo system, produces a picture with a minimum of time base instability (jitter). This time base instability can be further reduced by using a time base corrector (not available from Panasonic). The video signal produced by the NV-9240 can be thought of as consisting of a chrominance (color) portion, and a luminance (black and white or brightness) portion. Normally, an Automatic Phase Control (APC) circuit within the VCR removes all phase instability from the chrominance portion of the video signal. The luminance portion is untreated, and so it is this part of the video signal which has time base instability. Strictly speaking, the exact relationship between the chrominance and luminance portions (called interleaving) is not preserved by the VCR. This condition is common to all helical scan video tape recorders.
Many time base correctors allow the interleaving relationship of chrominance and luminance to be preserved. Such a time base corrector develops a subcarrier output signal (VTR 3.58) which if connected to Sub Carrier Connector of the NV-9240, serves as a reference for the APC circuit. This results in a video signal from the output of the time base corrector with almost no time base instability and nearly perfect interleaving of chrominance and luminance.
The time base corrector may be equipped with a dropout compensator to minimize the dropouts in the incoming video signal. The model NV-9240 supplies an RF video signal which is directly amplified from the video heads, enabling the time base corrector to function as a dropout compensator. By setting the DOC Switch provided on VCR at "OFF" position, the dropout compensator in the time base corrector will work to minimize dropouts.

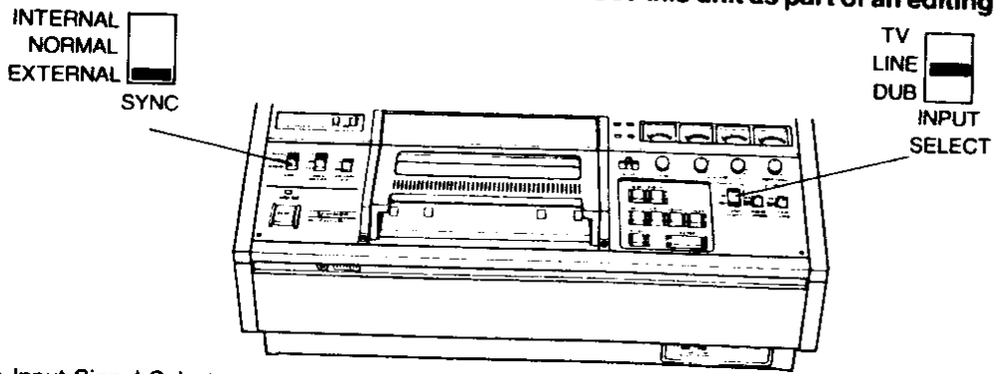
1. Connecting the Time Base Corrector

Connect the time base corrector (not available from Panasonic) as shown below.



Note:
It is recommended that DOC Switch is set at "ON" position if the TBC does not have provision for dropout compensation.

2. For normal Playback set each switch as shown below. Use this unit as part of an editing system.

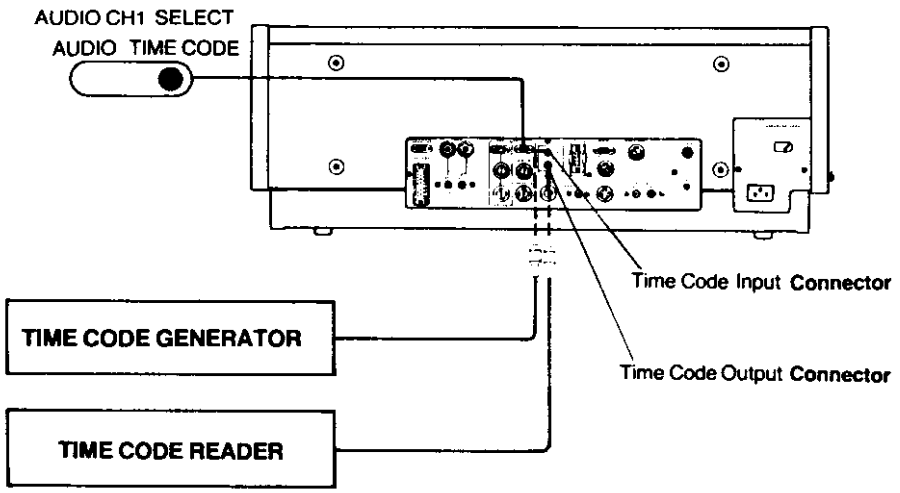


Notes:

1. With the Input Signal Selector set at "LINE", the APC and the noise eliminator circuits within the VCR function. This is desired regardless of whether your time base corrector provides a VTR 3.58 output.
2. With the Sync Mode Selector set at "EXTERNAL", the NV-9240 is locked to the advanced sync signal developed in the time corrector. The time base corrector inserts a certain amount of delay for the video information, and by locking the NV-9240 to advanced sync, proper phase with respect to vertical sync is maintained at the output of the time base corrector.
3. If it is desired to lock to an external sync source when using a time base corrector, connect the external sync signal to the time base corrector only, not to the NV-9240. The advanced sync output of the time base corrector should then drive the NV-9240 as explained in note 2.

ABOUT THE TIME CODE

In order to record the SMPTE TIME CODE signal, connect the SMPTE time code generator to the Time Code Input during recording, and select "time code". Then time code signal will be recorded on the audio CH1 track of the tape.



Note:

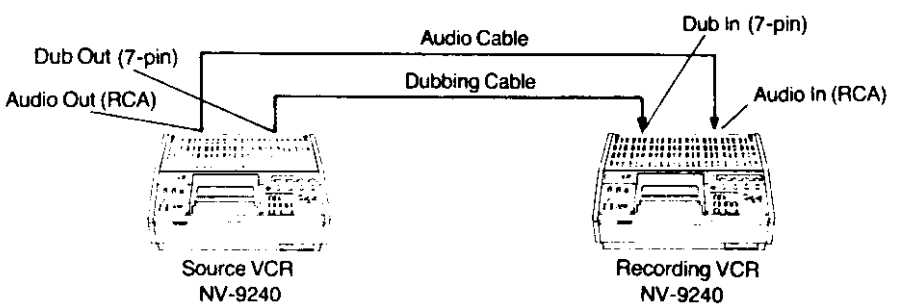
●When recording or playback of TIME CODE signal, set the Audio (CH1) Selector to "TIME CODE" position.

DUBBING SYSTEM

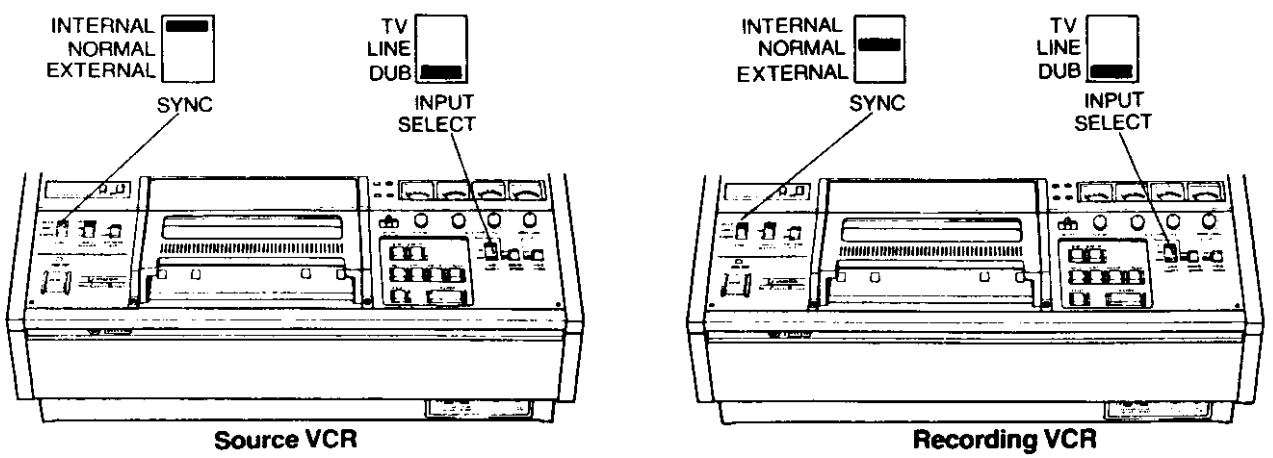
Two NV-9240 VCR's can be used for duplicating tapes (dubbing).

Basic Dubbing System

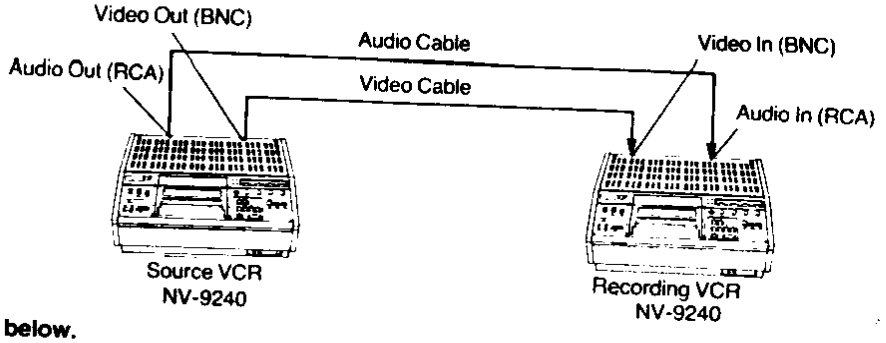
1) When Dubbing Cable (7-pin) is used



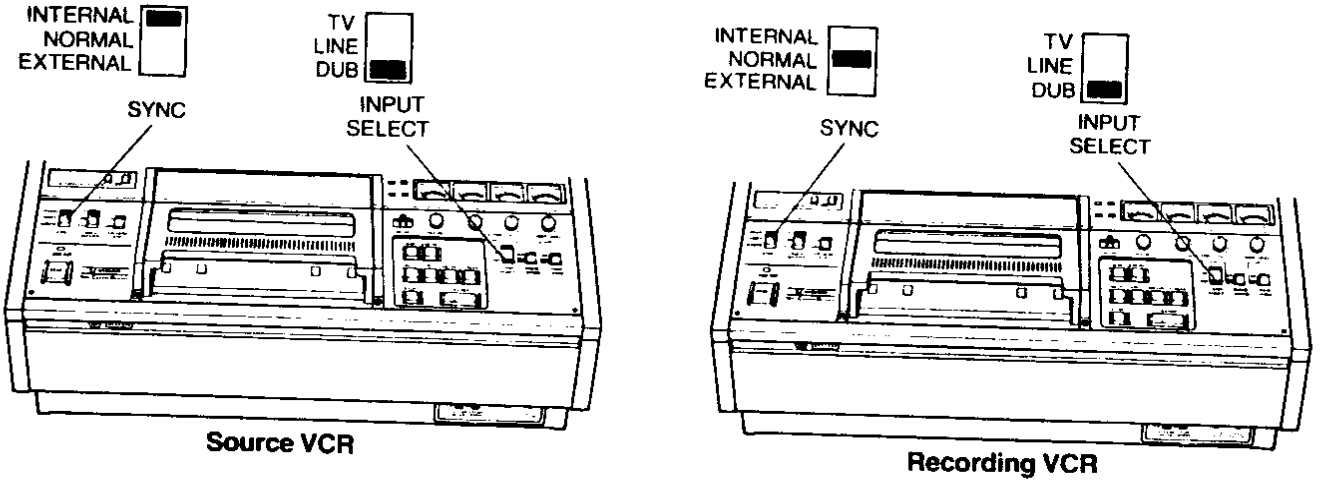
Set each switch as shown below.



2) When BNC video cable is used



Set each switch as shown below.



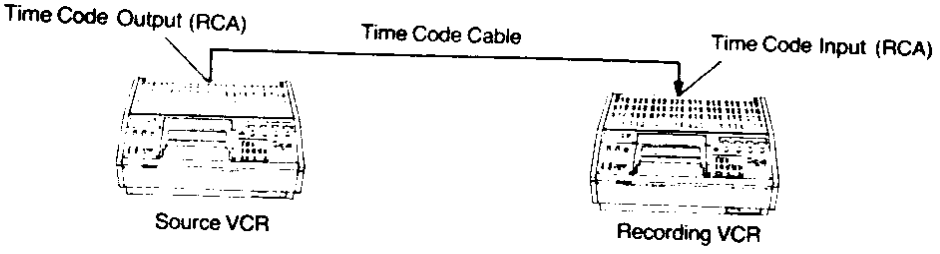
Note:

With the Input Signal Selector for source VCR set to "DUB", the APC circuit for the source VCR does not function. Therefore the chrominance portion will have the same instability as the luminance portion of the output signal, and the two portions will be perfectly interleaving, and this is the way it will be recorded by the recording VCR.

Ultimately, when the tape is played back, the chrominance portion will pass through the APC circuit of whatever VCR it is played back removing chrominance instability. However, since the chrominance and luminance information actually recorded on the tape is interleaved (APC and the noise eliminator circuits of source machine were shut off), the final playback will show less color noise and good quality picture.

3) Recording of Time Code

In case of recording the time code from the source VCR to the recording VCR, connect as follows;



Note:

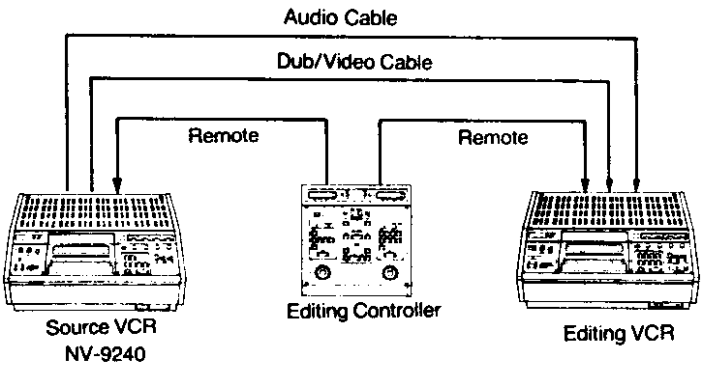
When recording or playback of TIME CODE signal, set the Audio (CH1) Selector to "TIME CODE" position.

USING THE NV-9240 AS PART OF AN EDITING SYSTEM

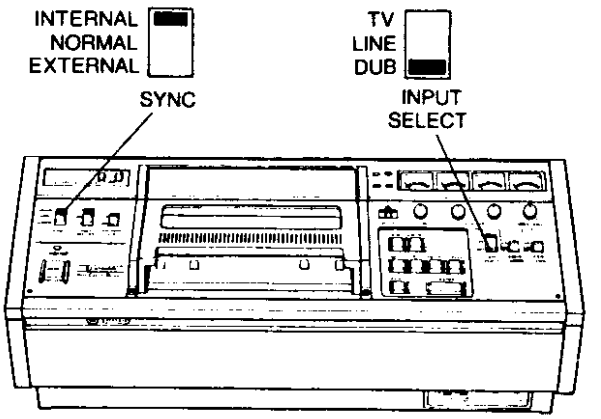
The NV-9240 itself is not capable of performing edit. However, its Direct Drive Head Cylinder and Capstan Servo provide tremendous stability and allow external synchronization, making it an ideal source machine as part of an editing system. Furthermore the NV-9240 is compatible for use with the Editing Controller (NV-A950/A960) or Auto Editing Controller AU-70 for automatic edits. Video cassette designed for still frame playback must be used in the editing system.

EDITING SYSTEM CONFIGURATIONS

1. Basic Editing System



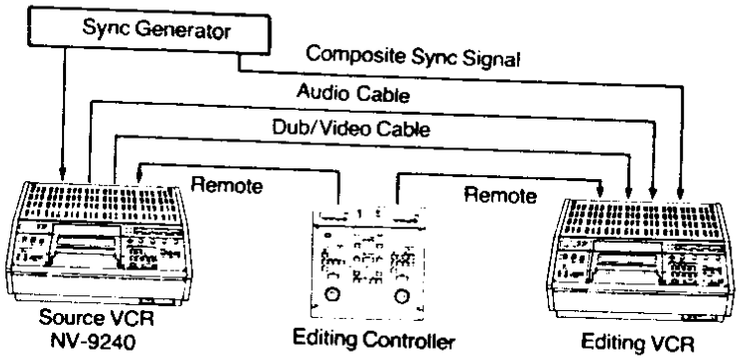
Set each switch on NV-9240 as shown below.



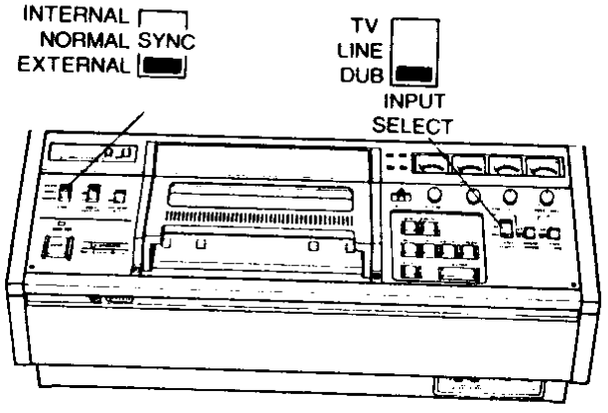
Notes:

1. With the Input Signal Selector for NV-9240 set at "DUB", the color APC and noise eliminator circuits do not function. This is desired for the same reasons explained in Dubbing System 2), note (page 20).
2. With the Sync Mode Selector set at "INTERNAL", the NV-9240 will be locked to its internal 60 Hz oscillator (derived from internal crystal source).

2. Editing System locked to External Sync Source



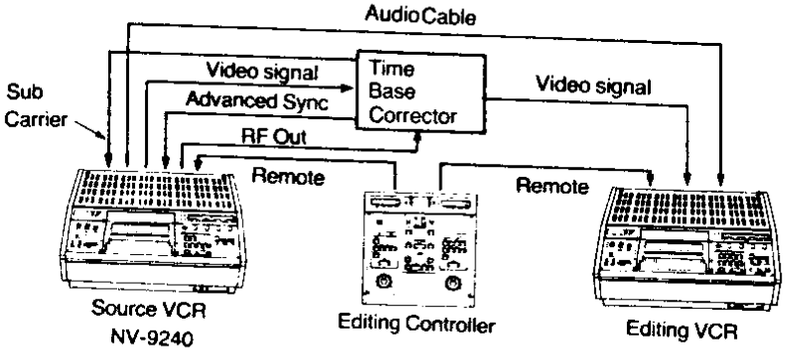
Set each switch on NV-9240 as shown below.



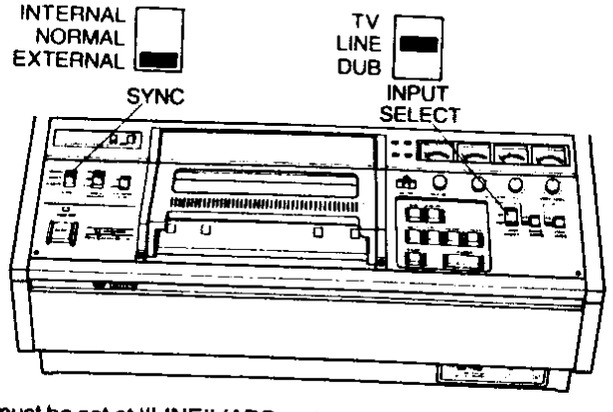
Notes:

1. With the Input Signal Selector for NV-9240 should be set at "DUB" for the same reasons as described in Dubbing System 2), note (page 20).
2. Setting the Sync Mode Selector at "EXTERNAL", allows the externally connected composite sync signal to drive the source VCR as well as the editing VCR.

3. Using a Time Base Corrector as part of an Editing System



Set each switch on NV-9240 as shown below.

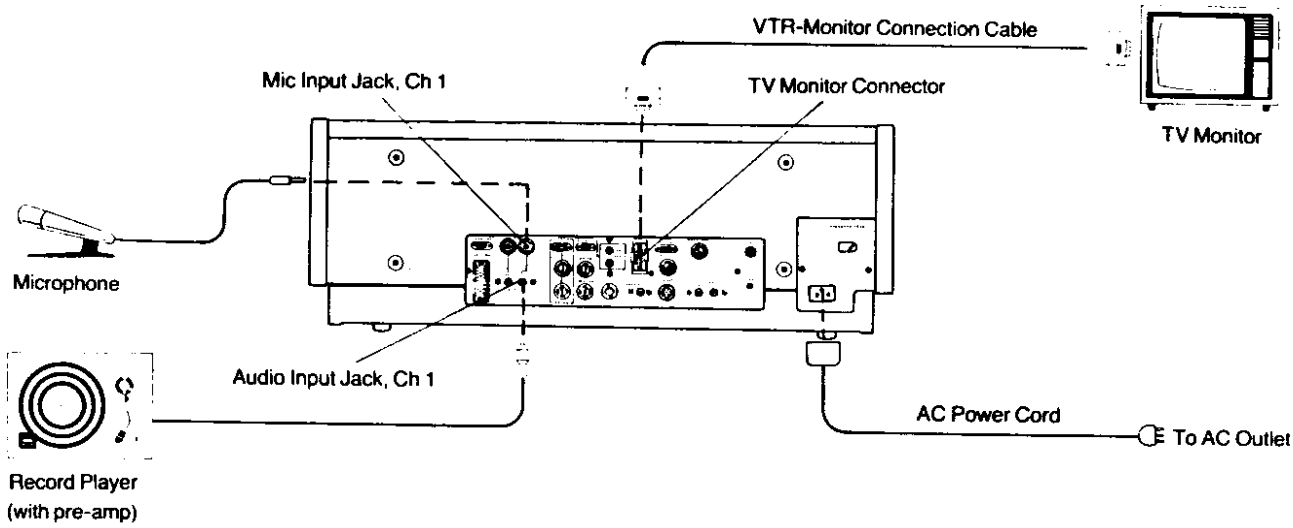


Note:

The Input Signal Selector for NV-9240 must be set at "LINE" (APC and noise eliminator circuits function), because the subcarrier signal developed by the time base corrector and fed back to the source VCR creates interleaving.

AUDIO DUBBING

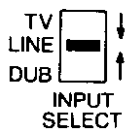
Audio dubbing allows an audio Channel 1 recording to be made on a pre-recorded tape.
In this way, pre-recorded video and audio Channel 2 will not be disturbed.



Notes:

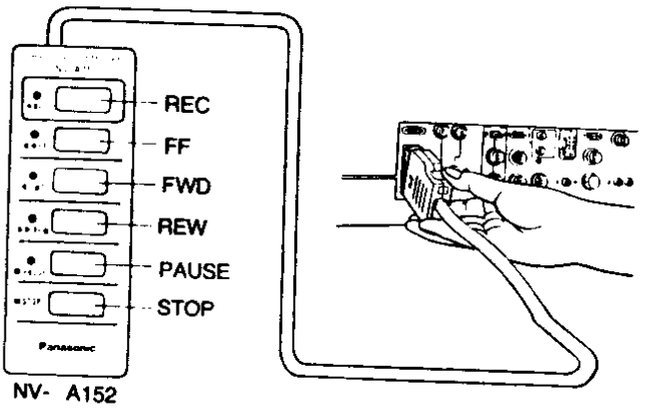
- Audio dubbing can be made on audio Ch 1 only.
  If you want to record TIME CODE signal, please refer to page 19, "ABOUT THE TIME CODE".
- Whenever the microphone and line inputs are connected at same time, the line input is internally disconnected and only the microphone is connected.
- If the red record button is missing from the bottom of the video cassette tape, no audio dubbing can be made. (See page 8.)

1. **Set the Input Signal Selector to the "LINE" position.**



2. **Press the Play Button.**
3. **Press the Play Button and the Audio Dubbing Button at any desired part.**
4. **Press the Stop, Rewind or FF Button as you desire.**

USING THE REMOTE CONTROL



NV- A152

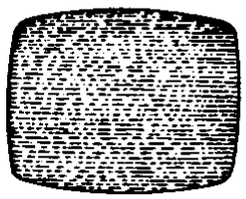
- If the optional remote control (NV-A152) is connected to the Remote Control Connector, record, forward, fast forward, rewind, pause and stop modes can be performed from a distance.
- The controls on the VCR can still be used even when the optional remote control (NV-A152) is connected.
- There are two models of optional remote control units which can be used with this VCR; model NV-A152 designed primarily for use with NV-9000 series VCR's and NV-A150 designed primarily for use with the older NV-2000 series VCR's.
  It is recommended to use the optional remote control, model NV-A152 for the NV-9000 series 3/4" VCR's.
  For detailed information regarding operation of the remote control unit, refer to the operating instructions of the remote control unit.

FUNCTION CHART WHEN COMBINING THE REMOTE CONTROLS AND 3/4" VCR's

Remote Control / 3/4" VCR	If used with NV-A152	If used with NV-A150
NV-9000 series	Full function (Recommended Combination)	No Fast Forward function
NV-2000 series	No Fast Forward function No Pause function	No Fast Forward function (Recommended Combination)

Note:
The remote control units have the following functions;
(A) NV-A152: Record, Forward, Fast Forward, Rewind, Pause, Stop.
(B) NV-A150: Record, Play (Forward), Rewind, Stop, Audio Dubbing.

HEAD CLEANING



When a grainy image is produced during playback, as shown in illustration, this is usually caused by a dirty video head. Clean the video head by using optional cleaning tape (NV-P20).

1. Load the optional cleaning tape (NV-P20) into the Cassette Compartment and press Play Button as if to play back the tape.
2. Allow the cleaning tape to run for 15 to 30 seconds, and press Eject Button.
3. Load and play back a pre-recorded tape known to be of good quality.
   If no improvement is noted, refer unit to qualified service personnel.

CAUTION:
Prolonged usage of the cleaning tape will shorten video head life.
Do not attempt to record or play back by using this cleaning tape.

CONDITIONS WHICH ARE APT TO BE MISTAKEN FOR A MALFUNCTION

Condition	Main cause and remedy
If there is no power to the unit . . .	•Is the AC power cord connected?
If no operation starts, when operation buttons are pressed.	•Is the Auto OFF Light on? See page 2.
If tape can't be rewound . . .	•Is the tape already completely rewound?
If the playback image is grainy . . .	•This is usually caused by a dirty video head. Clean the video head by using cleaning tape, Panasonic model NV-P20. See Head Cleaning instructions.
If the playback image is noisy	•Turn the Tracking Control. See page 13.
If there is no color image during playback . . .	•Is the Video Mode Switch set to the "AUTO"?
If the upper part of the playback image is slightly distorted . . .	•Slowly move the Skew Control to left or right. See page 13.
If the playback image is completely distorted . . .	•If the playback image is periodically completely distorted, check the following items: 1. Are radio interference and changes of power voltage intense during recording? 2. Is horizontal control of TV monitor set correctly? 3. Is the cassette tape defective?

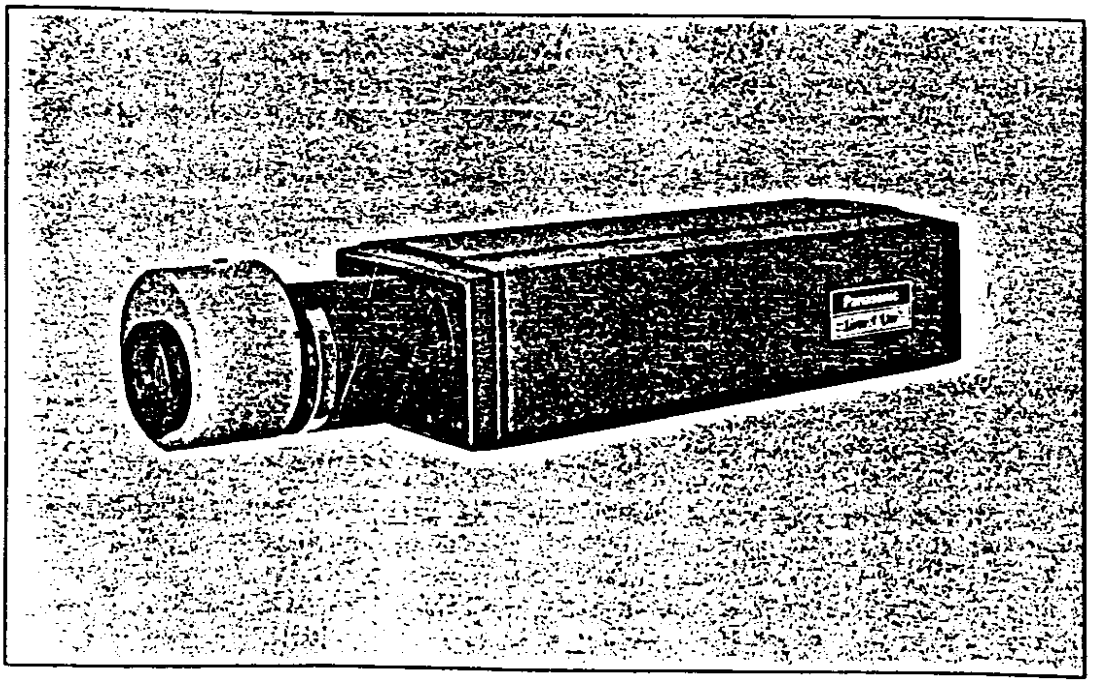
SPECIFICATIONS

Power Source:	AC 100/120/220/240V (Selectable), 50/60 Hz		
Power Consumption:	Approx. 130 watts		
Television System:	EIA Standard (525 lines, 60 fields) NTSC color signal		
Video Recording System:	2 rotary heads, helical scanning system		
	Luminance: frequency modulation recording		
	Color signal: converted subcarrier, direct recording		
Audio Track:	2 tracks		
Tape Format:	Tape width 3/4 inch (19 mm), high density tape		
Tape Speed:	3-3/4 i.p.s. (95.3 mm/s)		
Record/Playback Time:	60 min. with NV-P26		
FF/REW Time:	Less than 5 .0 min. with NV-P26		
Heads:	Video: 2 rotary heads		
	Audio/Control: 1 stationary head		
	Control (P.B. only)/Time code (Rec/P.B.): 1 stationary head		
	Erase: 1 full track erase		
	1 audio track erase for audio dubbing		
Input Level:	Video: TV Monitor connector (8P)	1.0Vp-p,	75Ω unbalanced
	VIDEO IN connector (BNC)	1.0Vp-p,	75Ω unbalanced
	Dub In Connector (7P): chroma level	0.9Vp-p,	
	luminance level	1.0Vp-p,	
	Audio: TV Monitor connector (8P)	−20 dB,	100kΩ unbalanced
	MIC jack (PHONE)×2	−78 dB,	250Ω unbalanced
	LINE jack (RCA)×2	−20 dB,	100kΩ unbalanced
	Sub carrier: (BNC)	2.0Vp-p,	75Ω unbalanced
	Composite sync: (BNC)	4.0Vp-p, negative pulse,	75Ω unbalanced
	Time code: (RCA)	1.0Vp-p,	10 kΩ unbalanced
Output Level:	Video: TV Monitor connector (8P)	1.0Vp-p,	75Ω unbalanced
	VIDEO OUT connector (BNC)	1.0Vp-p,	75Ω unbalanced
	Dub Out Connector (7P): chroma level	0.9Vp-p,	
	luminance level	1.0Vp-p,	
	Audio: TV Monitor connector (8P)	0 dB,	5kΩ unbalanced
	LINE OUT jack (RCA)×2	−6 dB,	600Ω unbalanced
	AUDIO MONITOR OUT jack (RCA)	0 dB,	5kΩ unbalanced
	HEADPHONE jack: High	−26 dB,	8Ω unbalanced
	Low	−32 dB,	8Ω unbalanced
	RF out: (BNC)	0.5Vp-p,	75Ω unbalanced
	Time code: (RCA)	2.4Vp-p,	low impedance unbalanced
Video Horizontal Resolution:	Color: better than 280 lines		
(on monoscope test pattern)	B/W: better than 500 lines		
Audio Frequency Response:	50~15,000 Hz		
Signal-to-Noise Ratio:	Video: better than 48 dB (B/W)		
	(Rohde & Schwarz noise meter)		
	Audio: better than 48 dB		
Audio Cross Talk:	Better than 40 dB		
Operating Temperature:	41°F~104°F (5°~40°C)		
Operating Humidity:	35%~80%		
Weight:	77 lbs. (35 kg)		
Dimensions:	26-1/8"(W)×9-3/8"(H)×18-3/4"(D)		
	661(W)×238(H)×475(D) mm		
Standard Accessories:	1 pc. AC power cord, VJA0129		
(supplied)			
Optional Accessories:	1 pc. Dust cover, VFB0006		
	3/4" video cassette tape: NV-P23 Approx. 610 ft. (186m), 30 min.		
	NV-P26 Approx. 1,175 ft. (358m), 60 min.		
	Head cleaning tape, NV-P20		
	Remote control unit, NV-A152		
	Editing controller, NV-A950		
	Editing controller, NV-A960		
	Auto editing controller, AU-A70		
	Multiple source adaptor, AU-J10		

Weight and dimensions shown are approximate.
Specifications are subject to change without notice.

Operating Instructions

Lunar Lite Camera
WV-1900/1904



Panasonic

Before attempting to connect or operate this product, please read these instructions completely.

CONTENTS

WARNING: TO PREVENT FIRE OR SHOCK HAZARD, DO NOT EXPOSE THIS APPLIANCE TO RAIN OR MOISTURE.

PREFACE

Panasonic introduces the WV-1900/WV-1904 black-and-white closed circuit Lunar Lite cameras which provide usable video pictures under moonlight conditions, designed for security and other specialized video applications where a minimum amount of light is required or desirable.

The Lunar Lite cameras are available in either standard 120 volt AC-powered version-model WV-1900, or low voltage 24 volt AC-powered version-model WV-1904.

The WV-1900/WV-1904 cameras incorporate highly sensitive 1" Newvicon® tube with fiber optics and an Image Intensifier (I.I.), which ensures high performance in minimum lighting conditions.

The WV-1900/WV-1904 cameras also feature: EIA standard RS-170 sync with LSI circuitry; various automatic control circuits for adjustment-free quality pictures; genlock capability through composite sync or a composite video signal; Auto-Black/AGC circuits for accurate, clear pictures in poor contrast situations: automatic internal/external sync switchover; built-in protection circuitry for the tube and image Intensifier; automatic control circuitry for the lens iris and the video gain; and a rugged die-cast chassis which protects the cameras from rough handling in normal usage.

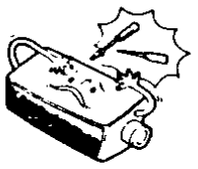
Besides security implementation, other applications include: certain industrial instrumentation applications; in mines and tunnels, and in docks or harbors where the camera is protected from moist or wet environment; various medical lab operations involving TV microscopy; engineering lab procedures requiring a minimum of light; and any security applications where extensive lighting is prohibitive.

FEATURES

1. Extremely high sensitivity operation
   - Usable picture : 3×10^{-4} footcandle (3×10^{-3} lux)
   - Recommended Illumination: 3×10^{-3} footcandle (3×10^{-2} lux)
2. High quality video pictures under extremely low light levels
   - Horizontal resolutions: 600 lines at center
   - Signal-to noise ratio: 45dB
3. Adjustment-free for considerable periods of time due to built-in automatic control circuits such as;
   - Automatic Beam Control (ABC)
   - Automatic Electronic Focus Control
   - Automatic Black Clamp Circuit
   - Automatic Gain Control (AGC)
4. Sharp pictures in poor contrast situations due to both the Automatic Black Clamp and Automatic Gain Control circuits.
5. High resistance to burn-in and blooming.
6. Protection circuits designed to protect both the Newvicon tube and image Intensifier from various sources of potential trouble.
7. Built-in RS-170 LSI sync generator.
8. Genlock feature for use in multi-camera systems.
9. Any one of following three external sync signals can be used.
   - Composite sync
   - Composite Video Signal
   - Horizontal Drive and Vertical Drive
10. Automatic internal/external sync switchover operation.
11. Picture orientation is easily changed with internal connector, allowing complete flexibility in mounting position.
12. A number of external adjustments are possible such as;
    - Focus control
    - Beam Control
    - Gain Control
    - Pedestal Control
    - Flangeback Adjustment
13. Heavy duty die-cast chassis for assuring reliability and stability.
14. Three mounting holes on the bottom for various lens.

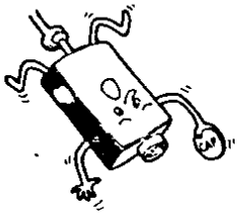
PRECAUTIONS

1. **Do not attempt to disassemble the camera.**
   To prevent electric shock, do not remove screws or cover. There are no user-serviceable parts inside. Refer servicing to qualified service personnel.



2. **Handle this camera with care**
   Avoid jarring or striking the camera as it contains a sensitive pick-up tube and the Image Intensifier (I.I.) which can be damaged by improper handling. Always keep the camera in a horizontal position when transporting.

3. **Lens and pick-up tube protection**
   When the camera is not in use, turn power off and insert the body cap into lens mounting hole when the lens is not installed.
   Avoid turning the power ON with the lens capped as this may shorten the life of the pick-up tube.

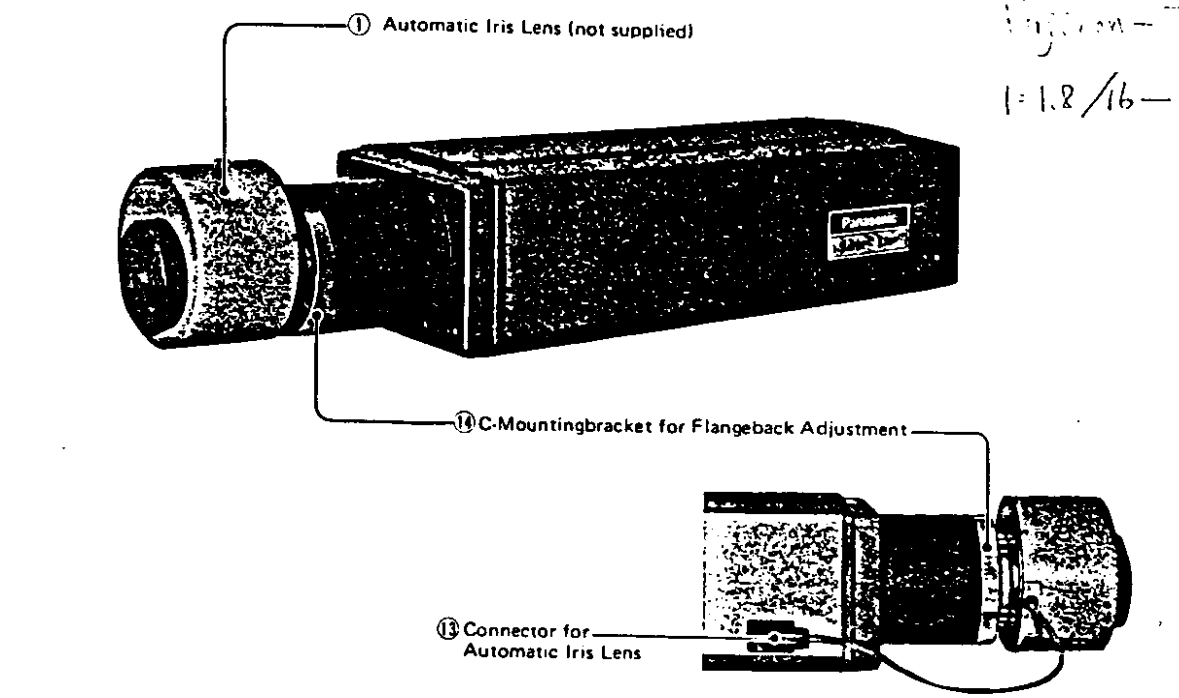


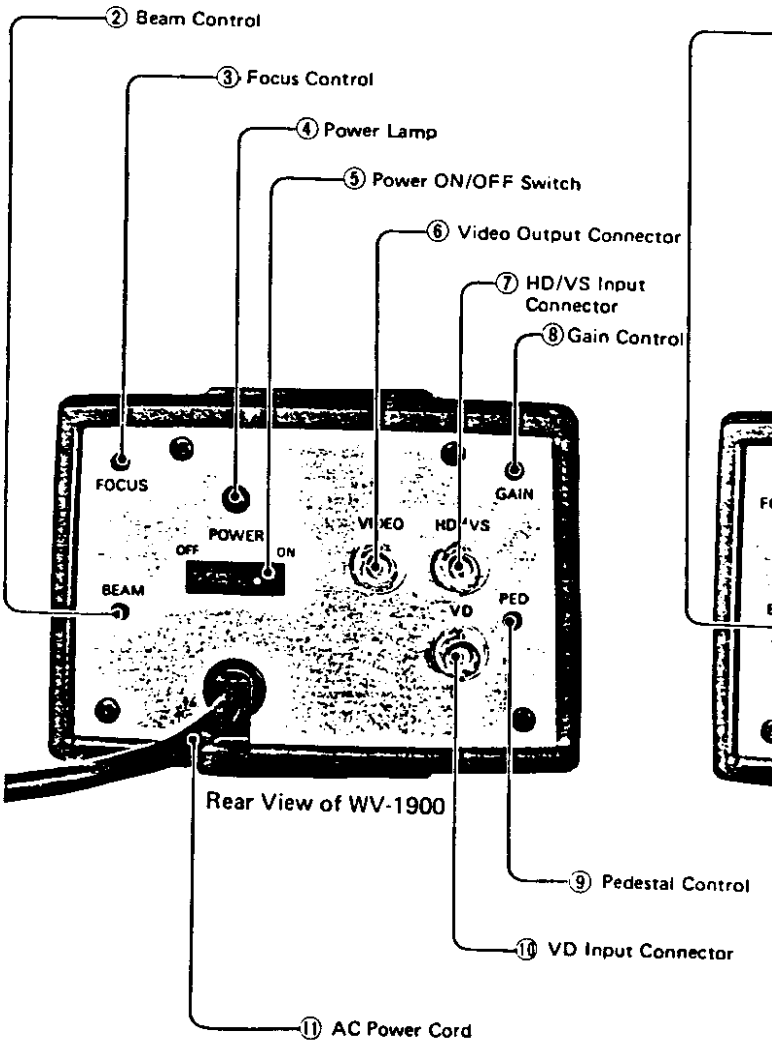
4. **Never face the camera toward the sun.**
   Whether the camera is in use or not, never face it toward the sun or an extremely bright object.
   This action could permanently damage the image intensifier (I.I.) and the pick-up tube.

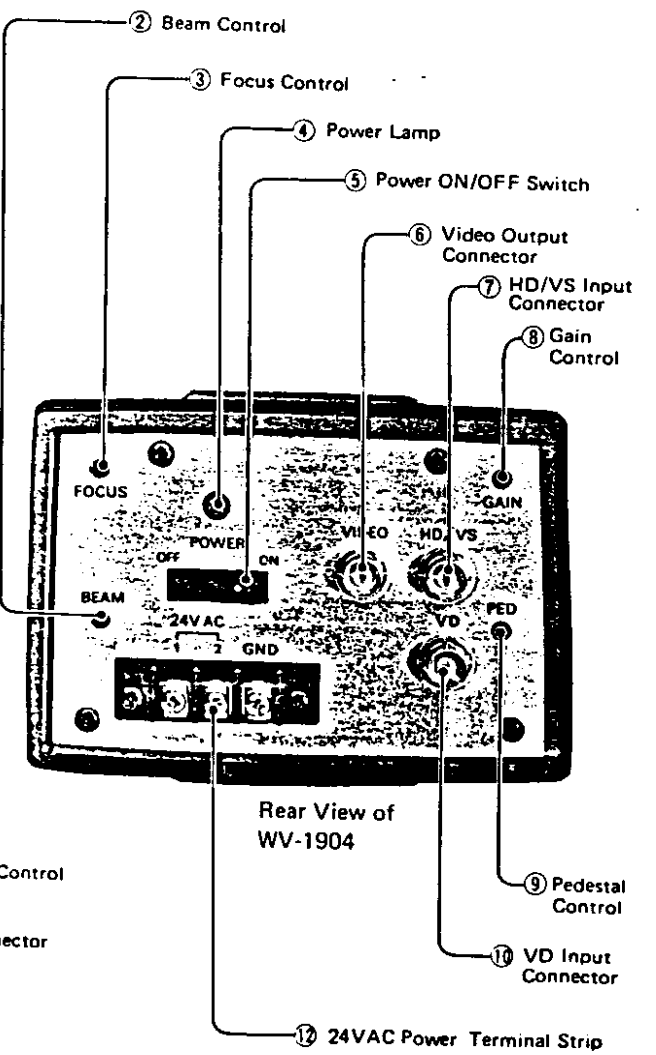
5. **Do not use the camera beyond its temperature, humidity or power source ratings.**
   (a) Designed for indoor use
   Ambient temperature must not range beyond 14°F~106°F (-10°~45°C)
   (b) Avoid using the camera when humidity is above 90%.
   (c) The input power source must be 120V±10% (108 ~ 132V) AC 60Hz for WV-1900, $24V^{+15\%}_{-20}$ (19 ~ 28V) AC 60Hz for WV-1904.

6. **Do not touch the surface of the image intensifier (I.I.)**
   If the surface of I.I. is dirty, use a mild dust blower or lens cleaning tissue (supplied) designed for coated lens, to clean the surface of I.I.
7. **Do not operate the camera without installing the lens under the light condition more than 0.05 footcandles (0.5 lux).**
   This can reduce the life of the image intensifier (I.I.)

MAJOR OPERATING CONTROLS AND THEIR FUNCTIONS







1. Lens (not supplied)
   Standard C mount automatic iris lens for 1" pick-up tube.

   Turn the lens focus ring while viewing the picture on the monitor and adjust for the clearest picture.
2. Beam Control [BEAM]
   For beam adjustment of pick-up tube. This control has been preset at the factory for optimum picture quality. Readjustment of this control should be made only by qualified service personnel. See page 11.
3. Focus Control [FOCUS]
   For electrical focus adjustment of pick-up tube.
   This control has been preset at the factory for optimum picture quality. Readjustment of this control should be made only by qualified service personnel. See page 11.
4. Power Lamp
   This lamp comes on whenever the unit is being operated.
5. Power ON/OFF Switch [POWER ON/OFF]
   This switch turns camera on and off.
6. Video Output Connector [VIDEO]
   Use a coaxial cable with a BNC connector. Video output signal is fed to a video monitor or VTR.
7. HD/VS Input Connector [HD/VS]
   The video signal of the camera is synchronized to the composite sync or composite video signal which is provided at this connector from external signal source.
   or
   The horizontal drive (HD) signal from the Special Effects Generator or Sync Generator is connected.
8. Gain Control [GAIN]
   For control of video output signal level.
   This control can vary the video output signal level by ±3dB against the nominal level 1.0Vp-p composite. This control has been preset at the factory for optimum picture quality.
   Readjustment of this control should be made only by qualified service personnel. See page 11.
9. Pedestal Control [PED]
   For control of pedestal level of video signal.
   This control has been preset at the factory for optimum picture quality.
   Readjustment of this control should be made only by qualified service personnel. See page 12.
10. VD Input Connector [VD]
    The vertical drive (VD) signal from the Special Effects Generator or Sync Generator is connected.
11. AC Power Cord – Models WV-1900
    3-wire power cord for connecting to power outlet (120V AC, 60Hz).

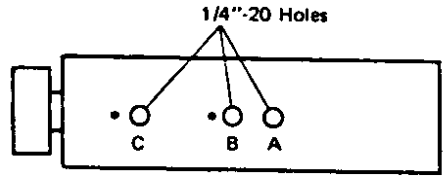
12. 24V AC Power Terminal Strip – Models WV-1904
    Accepts 24V AC power source. Be sure to connect grounding lead to the GND terminal.
    See page 8.

13. Connector for Automatic Iris Lens
    Supplies the power and video signal to the Automatic Iris Lens. The video signal will control the iris with the servo control circuit in the Automatic Iris Lens. See page 7.

14. C-Mountingbracket for Flangeback Adjustment
    By turning C-mountingbracket, the flangeback of the camera can be adjusted.
    The C-mountingbracket is fixed by three (3) screws.
    See page 11.

INSTALLATION OF CAMERA

- This camera can be mounted by using either of the three 1/4" — 20 holes on its bottom. These holes are of the standard photographic pan-head screw size.



- Selecting the proper Mounting Hole

  Hole (A): } For a short & light weight lens
  Hole (B): }
  Hole (C): For a long & heavy lens

  Selecting the proper mounting hole will give the camera better weight balance. If you mount the camera on a motorized pan/tilt head, proper weight balance will put less strain on the gears in the motorized head.

If camera is mounted upside down, the image on monitor TV will also be upside down. Therefore, refer to Qualified Service Personnel to perform the necessary internal adjustments. See page 12.

LENSES

(1) Selection of Lens

(A) Lens Mounting

C-mount Specified Automatic Iris Lens for 1" tube may be used.

(B) Focal length of lens vs. viewing dimensions

If object size and the distance between the object and the television camera are known, a lens of the proper focal length must be selected.

The proper focal length can be determined by the following equations or from the chart shown in the figure.

If a specific width is to be viewed: $f = 12.7\ L/W$

If a specific height is to be viewed: $f = 9.5\ L/H$

f: Focal length of lens (mm)

W: Object width (ft.)

H: Object height (ft.)

L: Distance between object and television camera. (ft.)

The length or width of an object, placed at a particular distance that can be picked up with a specific lens, can be calculated from the following equations or from the chart shown in the figure.

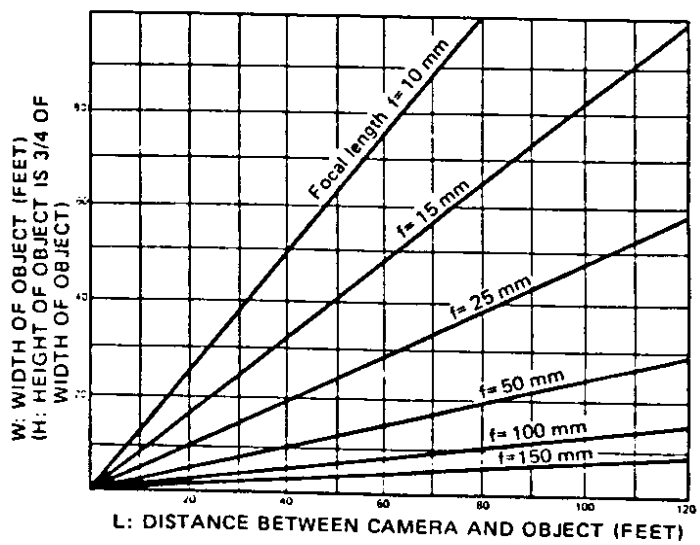
In case object width is important:

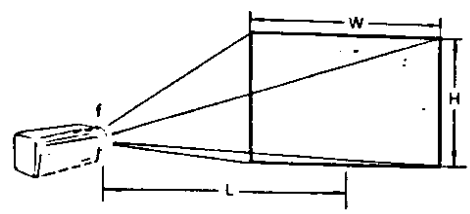
$$\text{(Approx.)} \quad W = \frac{12.7\ L}{f}$$

In case object height is important:

$$\text{(Approx.)} \quad W = \frac{9.5\ L}{f}$$

Note: Effective coverage angle will be 5 to 10% less of the following angle because video monitor is generally overscanned 5 to 10%.





W: Width of object (in Feet)
H: Height of object (in Feet)
L: Distance between camera and object (in Feet)
f: Required focal length (in mm)

(2) Specified Automatic Iris Lenses for 1" pick-up tube

If there is any variation of light, automatic iris lens must be used because the camera has no internal automatic light compensation.

For the iris control of the automatic iris lens, Panasonic Lunar Lite Cameras WV-1900/WV-1904 supply the power and video signal to the lens according to the following pin assignment:

Pin 1: Power: +12V DC, 60mA Max.
Pin 2: Ground
Pin 3: Open
Pin 4: Video Signal: 1.3Vp-p non composite/more than 100kΩ

- Iris characteristics of Specified Auto Iris Lens

Power Supply:	DC 12V (+30% ~ −10%) Minus Ground
Current Consumption.	30mA Max.
Input Signal:	Composite Video Signal or Video Signal
Input Impedance:	More than 100kΩ
Level Control Range.	0.3V ~ 0.9V (APL)
Note:	APL = Average Picture Level

Table for Specified Automatic Iris Lenses with C mount for 1" Pick-up Tube

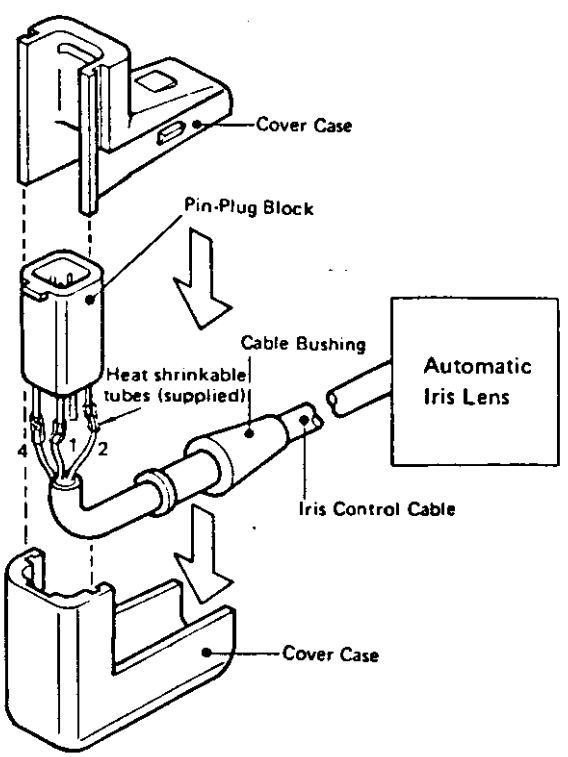
Specifications \ Model		CF12.5A–SNDP (Wide)	CF25B–SNDP (Standard)	CF50B–SNDP (Tele)	C10X16A, SNDP (Motorized Zoom)
Focal Length		12.5mm	25mm	50mm	16~160mm
Maximum Aperture		F1.4	F1.4	F1.4	F1.8
Iris Range (Built-in ND filter)		F1.4~T1500(Min)	F1.4~T1500 (Min)	F1.4~T1500 (Min)	F1.8~T1500(Min)
Automatic Light Compensation		1 : 10^7	1 : 10^7	1 : 10^7	1 : 5×10^6
Angular Field of View	H	54°13′	28°43′	14°35′	4°35′ at 160mm 43°36′ at 16mm
	V	42°00′	21°44′	10°58′	3°26′ at 160mm 33°24′ at 16mm
Minimum Object Distance		0.3m (1 ft)	1m (3.28 ft)	1m (3.28 ft)	1.8m (5.9 ft)
Power Source (Minus Ground) for Iris Control		+12V DC +30% ~ -10% 30mA Max.			
Optical Filter Size		φ55mm	φ49mm	φ49mm	φ101mm
Weight (Approx.)		1.1 lbs (490g)	1.1 lbs (480g)	1.1 lbs (510g)	7.5 lbs (3.4kg)
Dimensions		φ3-7/16" x 2-7/8" (φ88 x 73.25mm)	φ3-7/16" x 2-3/4" (φ88 x 70.25mm)	φ3-7/16"x2-15/16" (φ88x74.25mm)	φ5-3/8"x8-9/16" (φ137x217mm)
Wiring	Iris Control	Power Supply: Red Wire: +12V DC Video Signal: White Wire Common: Shield			
	Focus Control	None			+Far: Yellow Near: Brown
	Zoom Control	None			+Wide: Red Tele: Orange

(3) Installation of Automatic Iris Lens for 1" Pick-up Tube

The following installation should be made by qualified service personnel or system installers.

- Wiring Connector for Automatic Iris Lens

1. Install the cable bushing (supplied) on the iris control cable of the lens as shown in the figure and put the supplied heat shrinkable tubes on the wires of the iris control cable.
2. Solder the wires of the iris control cable at the pins of the pin-plug block according to the following pin assignment and cover the heat shrinkable tubes at soldered area and add the heat on tubes to shrink.
   - Pin 1: Power Source
   - Pin 2: Ground
   - Pin 3: Open
   - Pin 4: Video Signal
3. Install the pin-plug block into the cover case.
4. Both cover cases should be positioned to interlock and slide into each other until both cover cases are locked.



- Installation of Automatic Iris Lens

1. Mount the Automatic Iris Lens by turning it clockwise into the lens mount of the camera.
2. Connect the lens cable to the Connector for Automatic Iris Lens.
3. Focus the lens with the focus ring (black) of the lens.

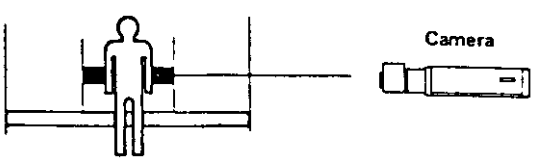
CAUTION:
Do not take off the black cap nor turn the screw. This is the sensitive control of the lens. See operating instructions of the lens for details. For adjustment refer to qualified service personnel only.

(4) Focusing of Automatic Iris Lens

When focusing on objects which are within a few meters (6½ ft.) from the camera, the iris should be fully opened. This can be accomplished by turning down illumination during initial installation. After focusing, provide normal illumination.

The reason for this procedure is as follows:

The range over which objects will stay in focus (depth of focus) changes with iris setting. If the object is brightly illuminated while focusing and the illumination reduces during certain periods of the day, the iris will automatically open to compensate. Now, the depth of focus is narrower and the object might no longer be in focus. If focusing is performed with the iris fully opened, you can be certain that the object will stay in focus regardless of changes in illumination.



(5) CAUTION AND REQUIREMENTS WHEN USING NON-AUTOMATIC IRIS LENS FOR 1" PICK-UP TUBE.

If object illumination is always constant, a lens other than an automatic iris lens may be used.

If object illumination changes even slightly when a lens other than an automatic iris lens is used, the video output signals will change considerably and no image may be reproduced in some cases. If all the conditions mentioned below (a~e) are met, then a lens other than an automatic iris lens may be used.

a) Sunlight will not directly come into the lens.

b) Used indoors only. (Not used outdoors)

c) Object illumination should be within the lens iris range.

d) Little change in object illumination.

e) Be sure to use a lens with an adjustable iris.

Set-up of Non-Automatic Iris Lens

Adjust the iris as follows:

a) Adjust object illumination to appropriate level.

b) Check image with a video monitor, and adjust lens iris to the best picture quality. The CONTRAST and BRIGHTNESS controls on the video monitor must be kept in the same position to which they have been adjusted with a television camera having an automatic sensitivity control.
(If you have an oscilloscope, adjust the lens iris to a position where video signal level will be 0.7Vp-p.)

c) The permissible range for object illumination is plus 20% and minus 75% of the level at which the camera was initially set-up. If object illumination varies in excess of this range, the image may bloom, or fail to show at all.

d) A little adjustment of the CONTRAST and BRIGHTNESS controls on the video monitor due to some change in illumination may be made on the video monitor whenever such adjustment is necessary. (If a motor driven zoom lens is used, the lens iris can be readjusted instead of the monitor controls.)

Note: Please test and check operation and image before final set-up.

ILLUMINATION

Generally, the greater the object illumination the higher will be the resulting picture quality. Ambient conditions, object reflection factor, pick-up tube spectral sensitivity loss, and loss of incoming light due to lens aperture ratio must all be considered. However the following illumination requirements must always be met.

- Minimum illumination required for rated equipment performance. (F1.4)
  3×10^{-4} footcandles (3×10^{-3} lux)
- Recommended illumination: (F1.4)
  3×10^{-3} footcandles (3×10^{-2} lux)

CONNECTIONS

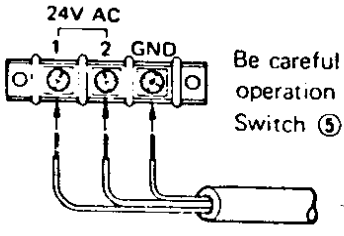
Power Cable

A. WV-1900

1. Keep the camera POWER switched OFF during installation.
2. Connect the AC Power Cord ⑪ to a 60 Hz grounded electrical outlet, 108V AC to 132VAC, preferably 120V AC.

B. WV-1904

1. Keep the camera POWER switched OFF during the installation.
2. A power supply of 24V AC 60 Hz is required.
3. Connect the power cable to the 24V AC Power Terminal Strip ⑫ on the rear panel of the camera.



Be careful not to obstruct the operation of Power ON/OFF Switch ⑤.

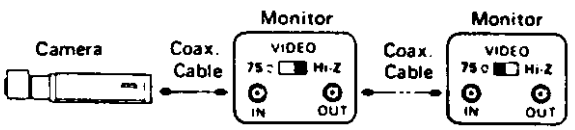
24 VAC $^{+15}_{-20}$%
(19~28V), 60Hz.

Recommended wire guage sizes for 24V AC line.

Copper wire size (AWG)	#24 (0.22mm²)	#22 (0.33mm²)	#20 (0.52mm²)	#18 (0.83mm²)
Length of Cable (Approx.) [ft]	200	325	500	825

Video Cable

1. Use a video monitor whose resolution is at least equal to the camera's.
2. Terminate the camera output in a 75Ω resistor at the furthest end of its cable run.
   A. Use 75Ω coaxial cable (RG-59, RG-59B/U, RG-59/U, RG-6/U or RG-11/U)
   B. Always set the last monitor's termination switch to 75Ω, and set the termination switches of intermediate monitors to HIGH.

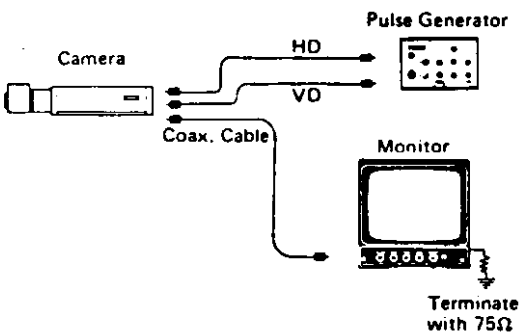


3. Wiring Precautions:
   - Do not bend coaxial cable into a curve whose radius is smaller than 10 times its diameter.
   - Never staple the cable – not even with circular staples. Mismatching will occur.
   - Never crush or pinch the cable.

   All these will change the impedance of the cable and cause poor picture quality.

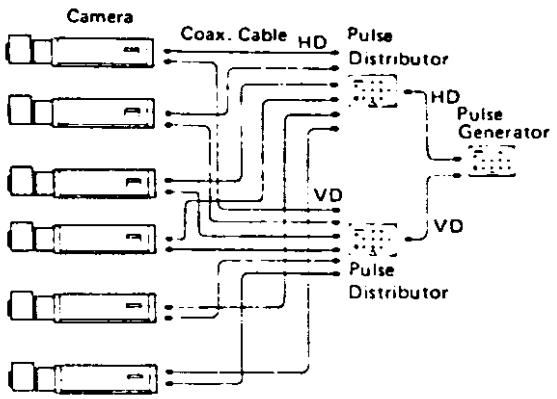
External Sync Cable

1. HD/VD sync.
   - The camera will be driven by external sync when the HD and VD coaxial cables are connected from the Pulse Generator.

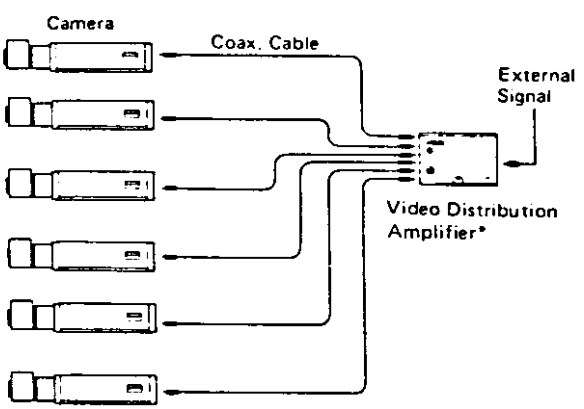


   - Pulse Generator can generate three sets of HD and VD pulses for 2:1 interlace for three cameras.
   - How to synchronize more than four cameras externally:

     Use two Pulse Distributors between the cameras and Pulse Generator. A pulse distribution amplifier receives, reshapes, and distributes HD or VD to six outputs. It is also equipped with an input loop-through circuit.
     Two units are always necessary to distribute HD and VD.



2. Composite Sync or Composite Video Signal
   - The camera will be genlocked by the external composite sync or composite video signal at HD/VS Input Connector *i* for multi-camera system.

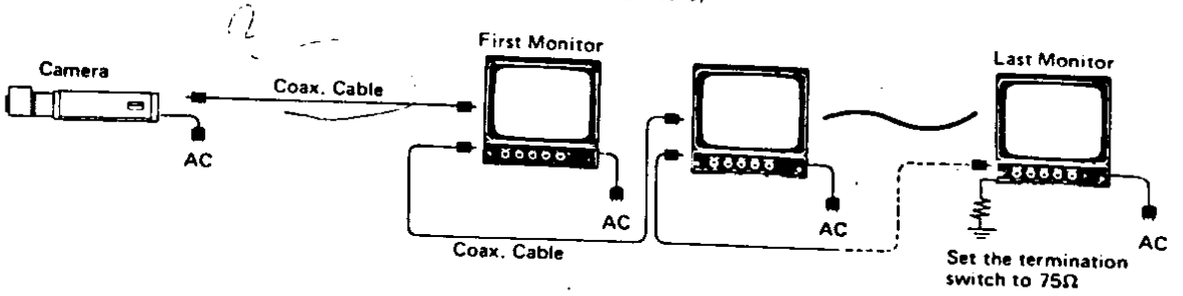


Note: The horizontal phase of some cameras might have to be adjusted to be in phase with the others.

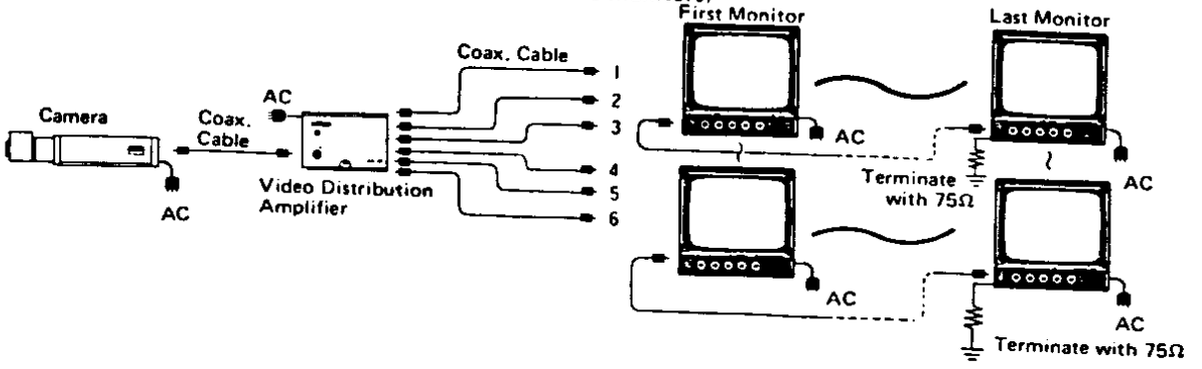
* The pulse distributor cannot be used to distribute video signal.

APPLICATIONS

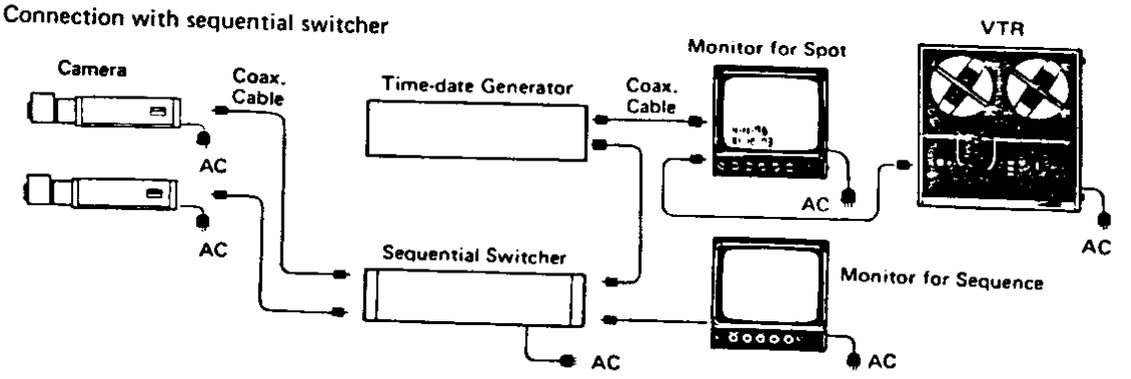
1. Connection with multiple video monitors (Less than 10 monitors)

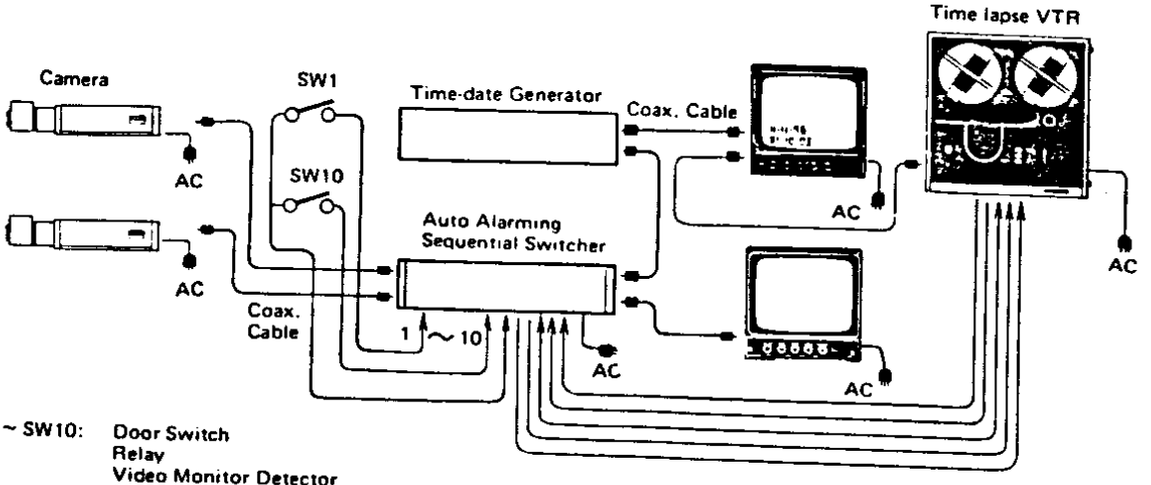


2. Connection with multiple video monitors (More than 10 monitors)



3. Connection with sequential switcher





SW1 ~ SW10: Door Switch
Relay
Video Monitor Detector
Photoelectric Tube Alarm

ADJUSTMENTS

CAUTION:

The following camera Adjustments must be made by qualified video service technicians or system installers.

1. Flangeback Adjustment

The C-mountingbracket on the camera is preset at factory so that the camera will focus from about 21.7 inches (55cm) to infinity with for 25mm lens (not supplied).

For a fixed focal lens, extreme closeups can be made by turning the C-mountingbracket clockwise.

The non-standard lenses can be also used easily by turning the C-mountingbracket clockwise or counter-clockwise.

The adjustments of the C-mountingbracket should be done as follows:

(1) Take off the lens from the camera if the lens is already installed.

(2) Loosen the three (3) screws on the C-monuting-bracket to facilitate turning.

(3) Install the lens into the loosened C-mounting-bracket.

(4) Turn the C-mountingbracket with lens to the desired position and mark the position.

(5) Try to take off the lens without moving the C-mountingbracket.

(6) Match the mark if the C-mountingbracket is moved, and tighten the three (3) screws on the C-mountingbracket for fixing.

For a zoom lens, usually no additional flangeback adjustment is needed.

If the focus at tele and wide or during zooming does not track, the flangeback adjustment must be performed by turning the C-mountingbracket as follows;

(1) Take off the zoom lens from the camera if the lens is already installed.

(2) Loosen the three (3) screws on the C-mounting-bracket for turning.

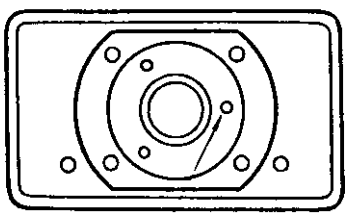
(3) Install the zoom lens into the loose C-mounting-bracket.

(4) Turn the C-mountingbracket with zoom lens where the zoom lens can be focused at tele and wide or during zooming.

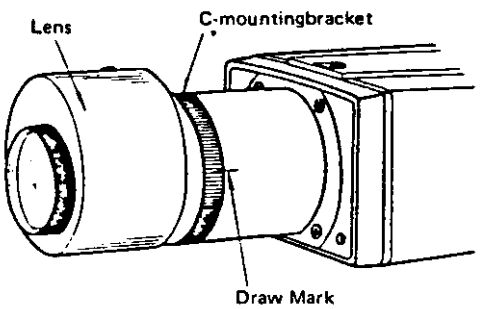
(5) Mark the position of C-mountingbracket.

(6) Try to take off the zoom lens without moving C-mountingbracket.

(7) Match the mark if the C-mountingbracket is moved, and tighten the three (3) screws on the C-mountingbracket to fix it.



Three (3) screws on the C-mountingbracket



2. Beam Control [BEAM] ②

Turn the Beam Control on the rear panel fully counterclockwise. Then turn it clockwise until the high-lights in the picture are just resolved, or discharged and advance the control slightly in the same direction.

3. Focus Control [FOCUS] ③

Turn the Focus Control on the rear panel slowly until picture on monitor is sharpest.

4. Gain Control [GAIN] ⑧

This control has been normally preset at the factory for video output level 1.0Vp-p composite.

This control can vary the video output level by ±3dB.

Observe the waveform of the video output signal on an oscilloscope and adiust the video output signal to be 1.0Vp-p composite.

5. Pedestal Control [PED]

This control has been preset at the factory.

Shoot the grayscale chart or the black and white chart. Observe the waveform of the video output signal on the oscilloscope and adjust the pedestal level of the video output signal to 0.07V level from the black level.

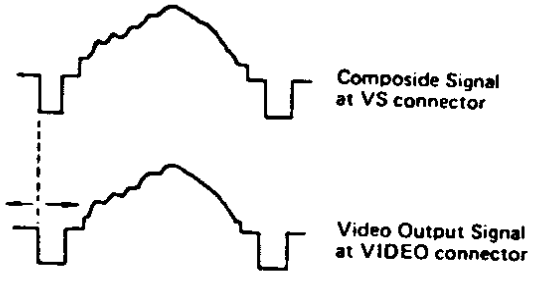
6. **Deflection Reversal (Internal)**

The internal deflection yoke reversal plug has been factory preset for normal position of the camera mounting on ceiling or wall brackets. If the camera is mounted upside down on ceiling or wall brackets, the picture on the monitor TV will also be upside down. In this case, reposition the deflection yoke reversal plug from CN203 on the PCB to CN202.

7. **H Phase Control (Internal)**

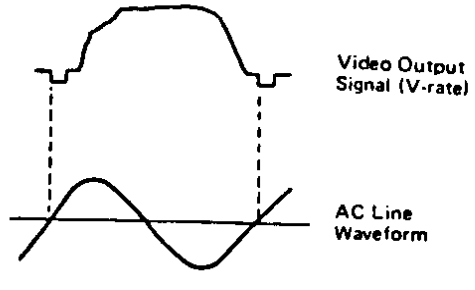
This control can adjust the horizontal phase of the camera video signal to match the H Phase of the reference signal. Its range is ±5μsec.

Observe the gen-lock in at VS connector and video output at VIDEO connector on the camera using a dual-trace oscilloscope or a waveform monitor and adjust H phase control on the PCB to line up the phase of both signals. Cable length difference affects this phase difference.



8. Line Phase Control (Internal)

This control can adjust the vertical phase of the camera video signal to match the phase of AC line. Observe the video output signal (V-rate) of the camera and AC line waveform using a dual-trace oscilloscope or waveform monitor and adjust V PHASE Control (VR) on the PCB to line up the phase of both signals.



SPECIFICATIONS

Power Source:	WV-1900 : 120V AC, 60Hz WV-1904 : 24V AC, 60Hz
Power Consumption:	WV-1900 : 20 Watts WV-1904 : 21 Watts
Pick-up Tube:	Incorporates First Generation Image Intensifier (I.I.) and Magnetic focus, magnetic deflection, separate mesh 1" Newvicon® tube with fiber optics, S4093
Scanning:	525 lines/60 fields/30 frames
Synchronizing:	Internal Sync : EIA RS-170 External Sync : Gen-Lock Input: Composite sync or composite video signal : Horizontal Drive (HD) and Vertical Drive (VD)
Horizontal Phase for Gen-Lock Adjustment Range:	±5μsec variable
Minimum Required Illumination: (with 2800°K incandescent lamp)	Usable picture (-20dB) : $3x10^{-4}$ footcandle ($3x10^{-3}$ lux) Recommended Illumination (−3dB): $3x10^{-3}$ footcandle ($3x10^{-2}$ lux)
Horizontal Resolution:	600 lines at center
Signal-to-Noise Ratio:	More than 45dB (AGC off, with 4.5MHz filter)
Gamma Correction:	0.7 (fixed)
Automatic Light Compensation: (with automatic iris lens, 25mm) F1.4~T1500 Min)	1 : 10^7 (AGC ON/Depend on the lens)
Video Output:	1.0Vp-p, 75 ohms composite, ±3dB variable
Geometric Distortion:	Less than 3%
Gray Scale Rendition:	Resolves 10 shades of gray
Lens Mounting:	Standard C Mount
Lens:	Specified standard C mount lens for 1" pick-up tube
Camera Mounting:	Three ¼"-20 threaded holes
Operating Temperature:	14°F to 106°F (-10°C to 45°C)
Dimensions:	5-1/4"(W) x 3-3/4"(H) x 17-1/4"(D) [134(W) x 96(H) x 438(D)mm]
Weight: Camera Body:	11.7 lbs (5.3 kg)

Weights and dimensions shown are approximate.
Specifications are subject to change without notice.

STANDARD ACCESSORIES

- ALC Lens Connector (YWRP97P4P) ..... 1 pc
- Lens Cleaning Tissue (YWFP10) ..... 1 pc
- Body Cap (YWBC-2B) ..... 1 pc

PANASONIC COMPANY, Division of Matsushita Electric Corporation of America

Executive Office: One Panasonic Way, Secaucus, New Jersey 07094 (201) 348-7000

Video Systems Division Executive Office: One Panasonic Way, Secaucus, New Jersey 07094 (201) 348-7000

Eastern Regional Office: Panasonic Video Systems, 50 Meadowlands Parkway, Secaucus, New Jersey 07094 (201) 348-7627

Midwest Regional Office: Panasonic Video Systems, 425 East Algonquin Road, Arlington Heights, Illinois 60005 (312) 364-7900

Southeast Regional Office: Panasonic Video Systems, 3 Meca Way, Norcross, Georgia 30093 (404) 923-3663

Southwest Regional Office: Panasonic Video Systems, 1625 Walnut Hill Lane Irving, Texas 75062 (214) 258-2828

PANASONIC WEST INC., Video Systems

8383 Wilshire Blvd, Beverly Hills, California 90211 (213) 655-1111

PANASONIC HAWAII INC.

320 Waiakamilo Road, Honolulu, Hawaii 96817 (808) 847-5361

PANASONIC CANADA, Division of Matsushita Electric of Canada Limited

5770 Ambler Drive, Mississauga, Ontario, Canada L4W 2T3 (416) 624-5010

PANASONIC SALES COMPANY

Ave 65 de Infanteria, Km. 9.7, Victoria Industrial Park, Carolina, Puerto Rico 00630 (809) 769-4320

N1280-0 YWV1900PRB1 Printed in Japan